FISCAL YEAR

2019 INDUSTRIAL CAPABILITIES

REPORT TO CONGRESS

PREPARED BY:
OSD A&S INDUSTRIAL POLICY
JUNE 23, 2020

FISCAL YEAR

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REQUIREMENT

Section 2504 of Title 10, U.S.C., requires that the Secretary of Defense submit an annual report to the Committee on Armed Services of the Senate and to the Committee on Armed Services of the House of Representatives by March 1st of each year. The report is to include:

1. A description of the Departmental guidance prepared pursuant to section 2506 of this Title.
2. A description of the methods and analyses being undertaken by the DoD alone or in cooperation with other Federal agencies, to identify and address concerns regarding technological and industrial capabilities of the national technology and industrial base.
3. A description of the assessments prepared pursuant to section 2505 of this Title and other analyses used in developing the budget submission of the DoD for the next fiscal year.
4. Identification of each program designed to sustain specific essential technological and industrial capabilities and processes of the national technology and industrial base.

Senate Report 112-26 accompanying S. 1253, the NDAA for FY 2012, requires an annual report by April 1, to the congressional defense committees containing a prioritized list of potential investments required to address industrial base shortfalls to be expected to be funded by the Department in future years through the DPA Title III program.

This report simultaneously satisfies the requirements pursuant to Senate Report 112-26, accompanying the NDAA for FY 2012; and Title 10, U.S.C., section 2504 (as of the passage of the FY2019 NDAA). This report does not address section 2504(a) as amended by the FY2020 NDAA.

Beginning with FY2018, the annual industrial capabilities report also provides Congress with updates related to the implementation and execution of the industrial base risk mitigation strategies and follow-on efforts related to Executive Order 13806 on Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States. This report includes a summary of risk mitigation actions taken in FY2019, and the implementation status of EO 13806 recommendations in Appendix A marked as “Controlled Unclassified Information (CUI)/For Official Use Only (FOUO) .”[1]

FOREWORD

This report serves as the yearly update that describes the challenges and opportunities our defense industrial base (DIB) faces in the ever-changing global landscape. The discussion of those challenges and opportunities throughout this report reflects our industrial base picture prior to the COVID-19 pandemic, and therefore does not include any effects of COVID-19 on our industrial base. Next year's Industrial Capabilities Report (2020) will address the changed landscape, holistic industrial challenges, and lessons learned from the COVID-19 pandemic, which the U.S. Government is assessing at the time of publishing this document.

As you read this report, you will see the importance of our defense industrial base, which includes the entire supply chain. Strength and resiliency in our supply chain enables our nation to accomplish current readiness objectives and prepare for future requirements of great power competition as outlined in the National Defense Strategy (2018). Underlying all conventional military forces are vast webs of people, resources, industrial capability, and production capacity which collectively form a nation's defense industrial base. As critical enablers of combat power, defense industries have historically served as a prime target for adversaries and competitors,[2] which is an area of concern for military planners.

Since World War II, the defense industrial base has expanded from a national to a global footprint which includes an extended and intertwined supply chain between domestic and international partners. Businesses have consolidated, outsourced, or moved select operations offshore to meet business efficiency objectives on tighter controlled peacetime budgets. The endeavor to protect the supply chain and its resources, to include its skilled workforce, has become increasingly complex. The Department of Defense role is as a customer, investor, regulator, and partner of industry.

Our organization's purpose is to assess, promote, and protect the defense industrial base to ensure it can support our military, today and tomorrow. As we assess our industrial base, the two essential questions we aim to answer are, who is in our military's supply chain and if a company is not, do we want them in our supply chain? Using the Department of Defense authorities, we aim to promote businesses that align with the acquisition and sustainment requirements of our weapon systems through investments, especially in areas where the strengths of commercial markets and the needs of U.S. national defense don't naturally align. Finally, we protect domestic industry from malicious foreign influence through various authorities and mechanisms available to our office and to the Department.

The U.S. and its allies must approach the industrial base as an asset — investing in its continued growth and development, rather than waiting until it devolves into a liability. By preserving existing critical capabilities and rightsizing and investing in industry for emerging capabilities and requirements, the U.S. defense industrial base will continue to meet the needs of U.S. national defense for decades to come.

The most effective approach requires cooperation from our DIB, partners and allies, Congress, and all those who continue to benefit from the capabilities our industrial base provides.

Amy Y. Murray
Acting Deputy Assistant Secretary of Defense,
Industrial Policy (INDPOL)

INTRODUCTION

By law, the Secretary of Defense must submit an annual report to the Congressional Armed Services committees on the actions, investments, and assessments conducted in support of the U.S. defense industrial base (DIB), and planned investments under the DPA Title III program. This report, the Fiscal Year (FY) 2019 Industrial Capabilities Report, simultaneously satisfies these requirements pursuant to Title 10, U.S.C., section 2504, and Senate Report 112-26, accompanying the NDAA for FY2012.

The Office of Industrial Policy (INDPOL) within the Office of the Undersecretary of Defense for Acquisition and Sustainment (OUSD(A&S)) is tasked with compiling this report. However, there is an extensive list of stakeholders across the Office of the Secretary of Defense (OSD), Military Services, and other Federal agencies, whose assessments and knowledge provide critical contributions to the Industrial Capabilities Report and the ongoing work of INDPOL.

The FY2019 report provides updates on:

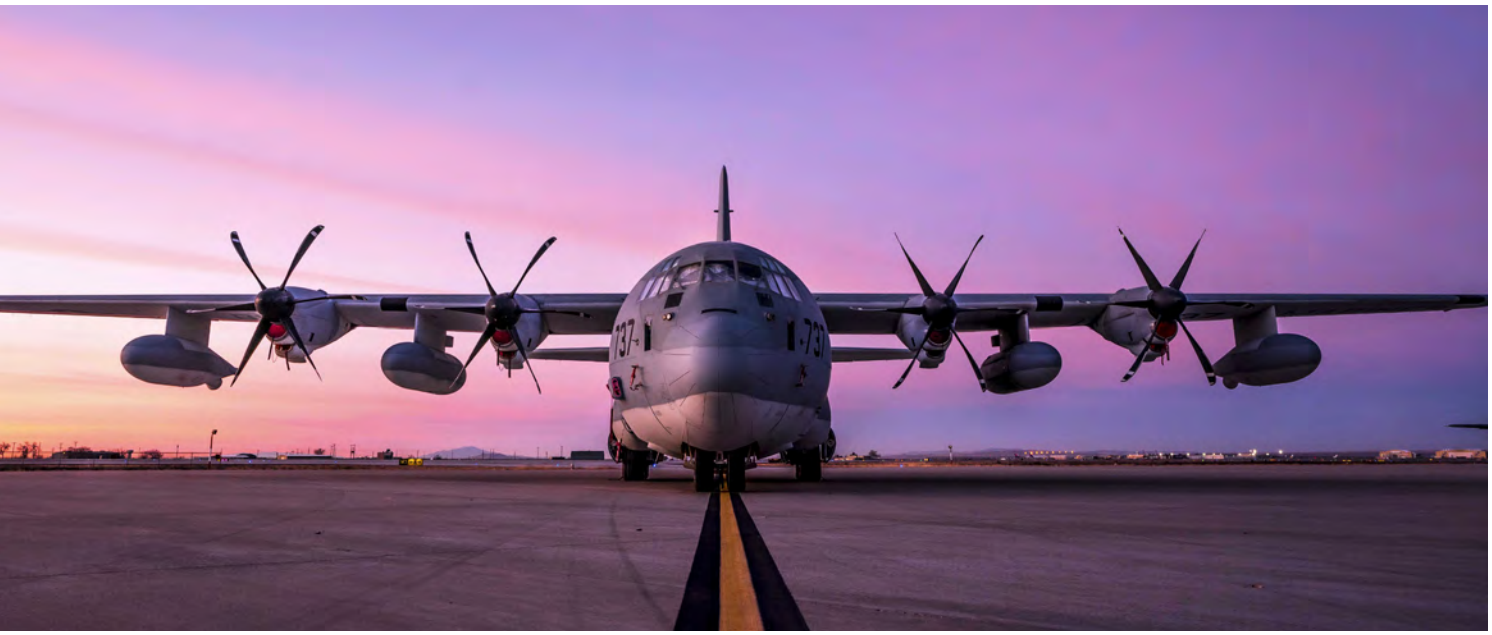
- New and ongoing initiatives within (A&S) INDPOL, and the Office of Technology & Manufacturing Industrial Base (TMIB) within OUSD Research and Engineering (OUSD(R&E))
- The state of the U.S. defense industry, including the financial strength and performance of largest U.S. defense contractors and general industry trends
- Assessments of risks facing the 16 U.S. Defense Industrial Base sectors, and updates pertaining to each
- Emerging technologies impacting the future defense industrial base
- Actions and authorities available to help mitigate risks to the U.S. industrial base (IB) and supply chains

The following appendices, which are marked "Controlled Unclassified Information (CUI)/For Official Use Only (FOUO),"[3] provide additional updates on:

- Risk mitigation actions and follow-on efforts related to Executive Order 13806 (Appendix A)
- Key industrial capabilities assessments conducted in FY2019 (Appendix C)
- Current and planned projects and investments within the DPA Title III, IBAS, and ManTech programs (Appendix D)

This report provides a snapshot of the health of the U.S. defense industrial base and the efforts and authorities intended to address identified risks. However, the industrial base and supply chains are constantly evolving with new requirements, business entrants, and competitors in the defense sphere. The U.S. must continue to strengthen and defend the U.S. defense industrial base across its supply chains in order to ensure it remains poised to meet the requirements of the National Defense Strategy and the challenges of renewed great power competition.

OFFICE OF INDUSTRIAL POLICY



DEPARTMENT OF DEFENSE OFFICE OF INDUSTRIAL POLICY (INDPOL)

Mission

The mission of the Office of Industrial Policy (INDPOL) is to ensure robust, secure, resilient, and innovative industrial capabilities upon which the Department of Defense (DoD) can rely to fulfill current and future warfighter requirements in an era of great power competition.

The national security of the United States requires the technological and intellectual capabilities of domestic and foreign companies, academia, and dual-use technology providers collaborating at the forefront of future generation technologies, along with the sub-tiers and components suppliers that support them. INDPOL serves as a hub for this diverse set of stakeholders to form an ecosystem that is committed to the health and vitality of the industrial base and the broader domestic economy, and represents DoD interests on interagency committees regarding business and economic issues relevant to national security.

Executive Order 13806

"Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States"[4]

From July 2017 – October 2018, INDPOL led the response to Executive Order (EO) 13806, Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States. The EO directed the Secretary of Defense to conduct a whole-of-government effort to assess risk, identify impacts, and propose recommendations in support of a healthy manufacturing and defense industrial base – a critical aspect of economic and national security. The assessment was directed with the recognition that in a renewed era of great power competition, the ability to arm our warfighters with the lethality and dominance to meet new and unforeseen strategic challenges is dependent upon a healthy and resilient defense industrial base. In October 2018, the DoD delivered its findings and recommendations to the President. Starting in FY2018, the annual Industrial Capabilities Report to Congress (required by 10 U.S. Code §2504) will provide updates on the implementation of the industrial base risk mitigation strategies and follow-on efforts related to EO 13806. As referenced, this report includes a FOUO summary of risk mitigation actions taken in FY2019, found in Appendix A.

Figure 1: Office of Industrial Policy (INDPOL) Organizational Chart

INDPOL ROLES AND AUTHORITIES

Policy and Outreach:

The Policy and Outreach team leads the strategic efforts for industrial base challenges for the Under Secretary of Defense for Acquisition and Sustainment (USD (A&S)), serves as the executive agent for the response to EO 13806, and conducts all industry engagement – both domestic and international – for the USD (A&S). The team leads implementation of the EO 13806 action plan, including creation of an industrial policy framework for DoD. Outreach efforts include biannual meetings with USD (A&S) and the CEOs of the largest defense prime contractors, quarterly meetings between OSD leadership and the major defense trade associations and their members, ad hoc meetings with small and mid-size companies (both traditional defense and those exploring DoD work as a new opportunity), and international trade shows. The team also leads INDPOL's international engagement efforts (see page 16), including government-to-government dialogue with allies and partners on joint industrial base concerns and areas of potential collaboration.

Assessments: Assessments integrates subject matter expertise, market analysis, and the principles of big data to identify industrial base risks and issues and establish mitigation strategies. This group covers three main areas:

Assessments

Assessments' subject matter experts work with DoD and interagency partners to identify, mitigate, and monitor risks and issues across the industrial base. Industrial sector summaries, fragility and criticality assessments, and capacity analyses inform the Department's budgetary, programmatic, and legislative policies in support of a strong and resilient industrial base.

Programs & Authorities:

- DPA Title I, Defense Priorities and Allocations System (DPAS) (see page 136)

Mergers & Acquisitions (M&A)

The M&A team leads DoD's acquisition review activity to determine which acquisitions are likely to be anticompetitive and/or have a negative impact to national security, and to challenge the parties involved at a time when remedial action is most effective.

Programs & Authorities:

- The Hart–Scott–Rodino Act (HSR) (see page 152)

Business Intelligence and Analytics (BI&A)

INDPOL's BI&A program supports proactive industrial base assessments through the development of data applications and data-driven analysis. The BI&A program draws on government, commercial, and open data sources to facilitate analysis of defense suppliers, sectors, and transactions and enhance visibility into defense supply chains.

Strategic Studies and Integration:

The Strategic Studies and Integration group was formed in FY2019. The group reviews and reports on critical technologies, develops programs to increase participation of small and medium companies in the manufacturing industrial base, and supports the development of integrated strategies across INDPOL and other offices in DoD.

Global Markets and Investments (GMI):

The GMI group manages the Committee on Foreign Investment in the United States (CFIUS) process for DoD. This group works with more than 30 stakeholders within DoD, as well as other government agencies, to review certain transactions involving foreign investment in the United States in order to assess the impact of such transactions on the national security of the United States. The group has a robust non-notified team, which is responsible for identifying transactions that were not voluntarily notified to CFIUS by leveraging a range of diverse analytical tools. They conduct intense analysis of both notified and non-notified transactions for national security risks.

Programs & Authorities:

- DPA Title VII (see page 140)
  - FY2019 NDAA, § 1701, Foreign Investment Risk Review Modernization Act (FIRRMA)

Industrial Base Analysis and Sustainment (IBAS):

The IBAS group enables investments to close gaps in defense manufacturing capabilities and creates and sustains reliable sources of supply that are critical to DoD's focus on readiness and lethality. The group concentrates on advancing and sustaining traditional defense manufacturing sectors, proactively mitigates supply chain vulnerabilities within the global DIB, plans for the next generation and emerging manufacturing and technology sectors, and leverages global manufacturing innovation through the development of partnerships.

Programs & Authorities:

- 10 U.S. Code § 2508, Industrial Base Analysis Fund (see page 144)

Office of Small Business Programs (OSBP):

- The OSBP group advises the Secretary of Defense on all small business matters and is responsible for maximizing opportunities for small businesses to contribute combat power for our troops and economic power for our nation. OSBP helps maximize opportunities to ensure that the nation's small businesses remain responsive, resilient, secure, and diversified. Group-managed initiatives, like the Mentor-Protégé Program (MPP), provide incentives for DoD contractors to support small businesses through enhanced capabilities and opportunities to increase their participation in government contracts.

Programs & Authorities:

- §831 of the FY1991 NDAA, Mentor-Protégé Program (see page 142)
- 25 USC § 1544, Indian Incentive Program (see page 142)

Defense Production Act (DPA) Title III:

The DPA Title III program is responsible for the development, maintenance, modernization, restoration, and expansion of domestic production capacity for critical components, technology items, materials, and industrial resources, to support national defense and homeland security requirements. Title III authorities may be employed when the President determines that domestic industrial capabilities essential to national defense do not exist, are at risk of being lost, or are insufficient to meet the needs of the U.S. national defense. Title III actions stimulate private investment in industrial resources by reducing the risks associated with the capitalization and investments required to establish the needed production capacity.

Programs & Authorities:

- DPA Title III (see page 138)

INTERNATIONAL ENGAGEMENT

"By working together with allies and partners we amass the greatest possible strength for the long-term advancement of our interests, maintaining favorable balances of power that deter aggression and support the stability that generates economic growth. When we pool resources and share responsibility for our common defense, our security burden becomes lighter. Our allies and partners provide complementary capabilities and forces along with unique perspectives, regional relationships, and information that improve our understanding of the environment and expand our options. Allies and partners also provide access to critical regions, supporting a widespread basing and logistics system that underpins the Department's global reach."

- 2018 National Defense Strategy

In alignment with the priorities of the 2018 National Defense Strategy, INDPOL's Policy and Outreach team coordinates government-to-government dialogue with allies and partners on joint industrial base concerns and areas for potential collaboration. INDPOL is the U.S. Government lead for the. National Technology and Industrial Base (NTIB), and the DoD lead for Security of Supply Arrangements (SOSAs) and Reciprocal Defense Procurement agreements. In addition, INDPOL facilitates engagements with partner governments and international industry partners through informal forums, such as international trade shows. Collectively, INDPOL provides an environment to facilitate sharing of information, technology, critical components, and materials across borders in support of national security requirements.

National Technology and Industrial Base (NTIB)

The NTIB is comprised of:

"The persons and organizations that are engaged in research, development, production, integration, services, or information technology activities conducted within the United States, the United Kingdom of Great Britain and Northern Ireland, Australia, and Canada."

- 10 U.S. Code §2500

NTIB Countries

- Australia
- Canada
- The United Kingdom
- United States

10 U.S. Code § 2500 was expanded in the FY2017 National Defense Authorization Act, adding the United Kingdom and Australia to the NTIB, which already included Canada and the United States. Since the expansion of the NTIB, INDPOL has worked bilaterally and multilaterally with its NTIB partners to identify barriers to integration of the NTIB supply chains and defense industrial bases. In May 2018, the NTIB partners signed a Statement of Principles, committing all four nations to meeting regularly to identify barriers to collaboration and facilitate changes to agreements (as appropriate) to further integrate the nations' industrial bases. In September 2019, the NTIB Terms of Reference document was executed, allowing more robust information sharing among NTIB partners, ahead of any formal agreements such as cooperative programs, project agreements, etc. The signing of the Terms of Reference has allowed NTIB partners to share information on activities like raw material sourcing, facilitating more robust project scoping.

During FY2019, there were three areas of focus within the NTIB – foreign direct investment screening, strategic and critical materials, and hypersonics. Each focus area included activities and projects in execution and under development, and all three facilitate the intent of the NTIB legislation, identifying and addressing barriers to facilitate integration of the supply chains and defense industrial bases of the four partner nations.

Security of Supply Arrangements

A Security of Supply Arrangement (SOSA) is a bilateral agreement that allows DoD to request priority delivery for contracts, subcontracts, or orders from companies domiciled in specific countries, and allows the signatory nation to request priority delivery for its contracts and orders with U.S. firms.

SOSAs – currently in place with nine countries – are conducted under the overarching Declarations of Principles for Enhanced Cooperation in Matters of Defense Equipment and Industry. These arrangements strengthen our alliances by encouraging participating nations to acquire defense goods from each other, promoting interoperability, and providing a mechanism to ensure mutual supply of defense goods and services during peacetime, emergencies, and armed conflict.

SOSA Countries

- Australia
- Canada
- Finland
- Italy
- The Netherlands
- Norway
- Spain
- Sweden
- United Kingdom

Reciprocal Defense Procurement Agreements

Under Reciprocal Defense Procurement agreements, countries afford each other certain benefits on a reciprocal basis, consistent with their national laws and regulations. Each Reciprocal Defense Procurement agreement provides a framework for ongoing communication between or among DoD and its respective counterparts regarding market access and procurement matters that contribute to effective defense cooperation. Key Reciprocal Defense Procurement agreement principles include fair competition, reduced market barriers, transparent processes, and protection of intellectual property. In addition, U.S.-based subsidiaries of foreign defense companies can leverage the support, intellectual property, and design capabilities of their foreign parent companies, as well the U.S.-unique capabilities developed under special security agreements or a proxy voting trust.

International Engagement in 2019

Throughout 2019, INDPOL provided support to DoD leadership through international engagement with partner nations, including but not limited to:

- Defense Technology and Trade Initiative (DTTI) Interagency Task Force Meeting (United States; January 2019)
- Aero India (India; February 2019)
- Australian International Airshow (Australia; March 2019)
- India-U.S. (DTTI) Group Meeting (United States; March 2019)
- Australia-United States Ministerial Consultation Defense Acquisition Committee Meeting (Australia; May 2019)
- Paris Airshow (France; June 2019)
- Defence and Security Equipment International (United Kingdom; September 2019)
- DTTI Interagency Task Force and DTTI Group Meetings (India; October 2019)
- Dubai Exhibition (United Arab Emirates; November 2019)

SUPPLY CHAIN RISK MANAGEMENT

The DOD Supply Chain

"The DoD supply chain, which includes DoD Components and the Defense Industrial Base, is the interconnected web of people, technology, information, and resources that get a product from suppliers to the warfighter."[5] It is responsible for every aspect of the design, production, delivery, operation, sustainment, and disposal of materials and technologies employed by the Department.

These supply chains are often long and increasingly complex. Globalization has extended supply chains across continents, making it challenging for the DoD to achieve visibility into product and information technology sources, and to achieve accountability of physical goods. Disruptions to the supply chain (whether intentional or unintentional) can impact readiness by delaying delivery of critical resources and equipment, and ultimately result in increased risk to the warfighter and U.S. national defense.

Supply Chain Risk Management

Supply chain risk management (SCRM) helps ensure access to goods and materials when and where they are needed through:

"[a] systematic process for managing supply chain risk by identifying susceptibilities, vulnerabilities and threats throughout DoD's "supply chain" and developing mitigation strategies to combat those threats whether presented by the supplier, the supplied product and its subcomponents, or the supply chain"

- DoD Instruction 5200.44

EO 13806, Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States, identified 10 risk archetypes that form a comprehensive overview of supply chain risk (see page 28).[6]

Supply chain threats can appear in any, or all, phases of a product's life cycle (including both hardware, and information-technology) and can include:

- "installation of intentionally harmful hardware or software (i.e., containing "malicious logic");
- installation of counterfeit hardware or software;
- failure or disruption in the production or distribution of critical products;
- reliance on malicious or unqualified service providers for the performance of technical services; and installation of hardware or software containing unintentional vulnerabilities, such as defective code"[7] or faulty equipment

These threats can have a range of impacts, including allowing adversaries to take control of systems or decreasing the availability of materials needed to develop systems, and leading to a loss of the confidentiality, integrity, or availability of federal systems and the information they contain. As such, the DoD (and government as a whole) has taken an increasing interest in protecting supply chains from physical and digital threats, and improving asset visibility and property accountability.

DOD Supply Chain Risk Management (SCRM) Initiatives:

Industrial Base Council (IBC)

Executive-Level forum for senior DoD leaders to review and discuss industrial base trends to provide an aggregated assessment on IB risk, prioritize and align IB efforts to DoD strategic priorities, leverage full authorities of the department, and develop policy to address IB vulnerabilities.

Trusted Foundry Program

In accordance with DoD Instruction 5200.44, Protection of Mission Critical Functions to Achieve Trusted Systems and Networks (TSN), the program "provides a cost-effective means to assure the integrity and confidentiality of integrated circuits during design and manufacturing while providing the US Government with access to leading edge microelectronics technologies for both Trusted and non-sensitive applications."[8]

Joint Industrial Base Working Group (JIBWG)/EO 13806 Implementation Task Force

Serves as the primary advisory group to the IBC. The JIBWG brings together DoD Services/Agencies and Government Department and Agency industrial base stakeholders to share, coordinate, and collaborate on defense industrial base risks and issues to develop proactive mitigation solutions in the interest of utilizing limited DoD industrial analysis resources most efficiently, and to minimize redundancy.

Diminishing Manufacturing Sources and Material Shortages (DMSMS) Working Group

The DMSMS working group facilitates the implementation of robust, strategic DMSMS management throughout the DoD in order to reduce, where possible, adverse impacts of DMSMS issues on readiness, schedule, and cost.

Parts Management Working Group (PMWG)

The PMWG establishes parts management best practices across DoD in order to increase weapon system availability and reduce total ownership costs. Selecting preferred parts during weapon system design drives positive outcomes throughout the life cycle of a program.

Cybersecurity Maturity Model Certification (CMMC)

Serves as a unified cybersecurity standard for the DoD Supply Chain to increase the cyber security posture of all DoD suppliers and reduce exfiltration of Controlled Unclassified Information (CUI).

Government-Industry Data Exchange Program (GIDEP)

GIDEP is "a cooperative activity between government and industry participants seeking to reduce or eliminate expenditures of resources by sharing technical information essential during research, design, development, production and operational phases of the life cycle of systems, facilities, and equipment. Proper utilization of GIDEP data can materially improve the total quality and reliability of systems and components during the acquisition and logistics phases of the life cycle and reduce costs in the development and manufacture of complex systems and equipment."[9]

Federal Acquisition Security Council (FASC)

The FASC is responsible for identifying and recommending development of standards, guidelines, and practices; identifying, and developing criteria for sharing information on supply chain risks as appropriate with stakeholders; issuing guidance on steps required to identify, assess, and respond to supply chain risks throughout the acquisition lifecycle; and establishing criteria and procedures for recommending the exclusion or removal of ICT suppliers or products from the Federal supply chain.

Recent Legislation/Policy

Section 881 of the FY2019 NDAA (Pub. L. 115-232)

Permanently authorizes "the use of supply chain risk as an evaluation factor in information technology procurements for services or supplies as a covered system, as a part of a covered system, or in support of a covered system." This authorizes the Secretary of Defense and Service Secretaries to:

1. exclude from the procurement "a source that fails to meet qualification standards established… for the purpose of reducing supply chain risk";
2. "[exclude] a source that fails to achieve an acceptable rating with regard to an evaluation factor providing for the consideration of supply chain risk in the evaluation of proposals for the award of a contract or the issuance of a delivery order"; or
3. "[decide] to withhold consent for a contractor to subcontract with a particular source or to direct a contractor for a covered system to exclude a particular source from consideration for a subcontract."

Strengthening and Enhancing Cyber-capabilities by Utilizing Risk Exposure Technology Act (SECURE Technology Act of 2018)

- Requires departments and agencies to maintain an organizational cybersecurity - SCRM program.
- Establishes the Federal Acquisition Security Council
- Authorizes executive agencies to exclude sources, from a single procurement or class of procurements, that fail to meet qualification requirements, or pose an otherwise unacceptable level of supply chain risk.

Conclusion

Supply Chain Risk Management has become more and more complex through great power competition—coupled with globalization of the supply chain. Mitigating supply chain vulnerabilities requires constant monitoring and attention, and future technology development will infuse a new set of supply chain risks where our competitors will continue to challenge us.

The DoD and our allies and partners must continue to work together to share technology advances and interoperability, and leverage various policy, legislative, procedural, and budgetary levels to strengthen U.S. supply chains.

WORKING GROUPS AND INTEGRATED PRODUCT TEAMS

To support DoD's goal to create an organizational structure that provides technical superiority and weapon systems affordability, OSD leads multiple working groups (WGs), committees, and Integrated Product Teams (IPTs). These groups are intended to share information between government stakeholders and industry, identify and prioritize risks, and accelerate the implementation of risk mitigation strategies. The following working groups, with the purpose, oversight, and participating members identified, were supported in FY2019:

Critical Energetic Materials Working Group (CEMWG)

Mission: CEMWG is the single focal point for the DoD for obsolescence issues for any chemical necessary for the synthesis and/or formulation of an energetic material (or its precursors) used in DoD systems. It assesses risk of supply and develops and implements mitigation plans for these risks. Funding for mitigations comes from OSD IBAS, DPA Title III, and ManTech investment programs, as well as Service funding from acquisition program offices.

Members: AMRDEC/WDI, Project Director Joint Services, NAWC China Lake, NSWC IHEODTD, AF/ Eglin AFB, AFLCMC/EBHCC, MDA/ECM, MDA/AB

Oversight: Office of Tactical Warfare Systems (TWS) & OUSD INDPOL

Joint Army Navy NASA Air Force Programmatic and Industrial Base Committee (JANNAF/PIB)

Mission: JANNAF PIB provides a forum for discussion of propulsion issues, challenges, and opportunities across the Military Departments, Defense Agencies and NASA. The Committee focuses on the technology, development, and production capabilities for all types of propulsion systems and energetics for tactical, strategic and missile defense rockets and missiles, for space boost and orbit transfer, for in-space propulsion, and for gun systems.

Members: Army, Navy, NASA, Air Force

Oversight: Member of PIB Executive Committee

Space Industrial Base Working Group (SIBWG)

Mission: SIBWG assesses risk, develops mitigation plans, and promotes management and procurement practices within the DoD and the Intelligence Community (IC) that ensure access to critical technologies required to meet the missions of the National Security Space community.

Members: INDPOL, AF SMC, NRO, MDA, NASA

Oversight: PDSAS & OUSD INDPOL

Joint Industrial Base Working Group (JIBWG)

Mission: JIBWG brings together the Military Services and Government agency industrial base stakeholders to share, coordinate, and collaborate on DIB issues in the interest of managing limited DoD industrial analysis resources, minimizing redundancy, and having an overall view of the industrial base risks impacting multiple stakeholders. JIBWG meets bi-annually or more frequently, as needed, to share IB analyses and propose new assessments.

Members: INDPOL, Joint Staff, Army, Navy, Air Force, Marines, DCMA, MDA, DLA, OASD(S)

Oversight: OUSD INDPOL & DCMA IAG

DoD Fuze Integrated Product Team

Mission: The DoD Fuze IPT was formed to establish and sustain viable U.S. fuze industrial bases. The IPT focuses on supporting science and technology, engineering development, test and evaluation, production, and sustainment of current and future DoD fuzes necessary to meet DoD munitions requirements.

Members: AT&L Land Warfare & Munitions, AT&L Manufacturing and Industrial Based Policy, AT&L Director of Defense Research & Engineering, AT&L DCMA, OSD Policy, Air Force, Army, Marine Corps., Navy, DoE Lawrence Livermore National Laboratory, DoE Los Alamos National Laboratory, DoE Sandia National Laboratories, DoE Kansas City National Security Campus (NSC)

Oversight: OUSD Defense Systems, Land Warfare & Munitions

Joint Munitions Power Sources Integrated Product Team (JMPS IPT)

Mission: The JMPS IPT was established to provide centralized leadership and advocacy for the research, development, and production of reliable munitions power sources to meet current and future Warfighter needs. The IPT fosters a community of munitions power expertise and implements the best available technology and production practices to spearhead advancements in power capabilities and enable enhanced munitions performance.

Members: SNL, CCDC Armaments Center Fuze Division, CCDC Armaments Center Fuze Management Office, DCMA Industrial Analysis Group, DCMA Technical Directorate Quality Assurance, CCDC Armaments Center Advanced Materials Technology Branch, NSWC IHEODTD, LLNL, NAWCWD, CCDC Army Research Laboratory, CCDC Aviation & Missile Center

Oversight: OUSD A&S

Parts Management Working Group

Mission: The PMWG was created to establish parts management best practices across DoD in order to increase weapon system availability and reduce total ownership costs. Selecting preferred parts during weapon system design drives positive outcomes throughout the life cycle of a program.

Members: Army, DAU, DCMA, DLA, DMEA, DSPO, EDU, FAA, GIDEP, IDA, LMI, MDA, NASA, NAVY, NOAA, OSD, USAF, USCG, USMC, WYLE

Oversight: Defense Standardization Program Office (DSPO)

Diminishing Manufacturing Sources and Material Shortages (DMSMS)

Mission: DMSMS was created to facilitate the implementation of robust, strategic DMSMS management throughout the DoD in order to reduce, where possible, adverse impacts of DMSMS issues on readiness, schedule, and cost.

Members: ARMY, DAU, DCMA, DHA, DLA, DMEA, FAA, MDA, NASA, NAVY, ODASD(MR), OSD, USAF, USCG, USMC

Oversight: OUSD (R&E)/Engineering Policy & Systems

Strategic Materials Protection Board (SMPB)

Mission: The SMPB determines the need to provide a long term secure supply of materials designated as critical to national security, analyze the risk associated with each material, and recommend a strategy to ensure a secure supply of materials designated as critical to national security is available.

Members: INDPOL, DLA, Army, Navy, AF

Oversight: OUSD INDPOL

Joint Expendable Countermeasures Integrated Product Team (JECM IPT)

Mission: The JECM IPT is focused on infrared expendable flares and supporting devices. It accomplishes this goal by leveraging new technology developments and procurement buys to sustain the workload of the industrial base, harmonize requirements among the services (to include inputs to requirement documents), and work toward a common joint countermeasure acquisition strategy.

Members: NAVAIR, AF, AFRL, NSWC Crane

Oversight: Navy, Army Picatinny, Air Force, AFLCMC/EBHCC

Defense Industrial Base Critical Infrastructure Government Coordinating Council (DIB-CI GCC)

Mission: The DIB-CI GCC Identifies items that need government-wide coordination and communication; needs and gaps in plans, programs, policies, procedures and strategies; acknowledges and recognizes successful programs and practices; and leverages complementary resources within government and between government and industry.

Members: OUSD INDPOL, Homeland Defense, National Guard Bureau, OUSD (R&E), DPC, USD(I), OUSD (P&R), ASD(NII)

Oversight: USD(P)

Joint Additive Manufacturing Steering Group

Mission: The Joint Additive Manufacturing Working Group disseminates information on the DoD's Additive Manufacturing efforts throughout the DoD Components and provides recommendations for the Joint Additive Manufacturing investment strategy.

Members: OSD (A&S), Military Services, DoD Components, and Joint Staff.

Oversight: OUSD (R&E) & OUSD (A&S)

EXECUTIVE ORDER 13806

EXECUTIVE ORDER (EO) 13806

Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States

OVERVIEW

On July 21, 2017, President Donald J. Trump signed EO 13806 on Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States. The EO directs the Secretary of Defense to conduct a whole-of-government effort to assess risks, identify impacts, and propose recommendations in support of a healthy manufacturing and defense industrial base – a critical aspect of economic and national security. The assessment was ordered with the recognition that in a renewed era of great power competition, the ability to arm and equip our warfighters to meet new and unforeseen strategic challenges is dependent upon a healthy and resilient defense industrial base.

The review took a team of roughly 300 subject matter experts over a year to complete. The findings were published in September 2018 and included a public report along with a FOUO annex detailing identified industrial base "impacts," and vulnerabilities. INDPOL reports on the status of the risk mitigation actions resulting from the review as part of the Industrial Capabilities report, and continues to apply the framework for continuous identification of industrial base risks.

Table 1: Industrial Based Sectors

Traditional Sectors	Cross-Cutting Sectors
– Aircraft – Chemical, Biological, Radiological, Nuclear – Ground Systems – Missiles and Munitions – Nuclear Matter Warheads – Radar and Electronic Warfare – Shipbuilding – Soldier Systems – Space	– Materials – Cybersecurity for Manufacturing – Electronics – Machine Tools – Organic Defense Industrial Base – Software Engineering – Workforce

PROCESS

An interagency task force, led by DoD's Office of Industrial Policy, created sixteen working groups (nine working groups focused on traditional sectors; seven working groups assessed enabling, cross-cutting capabilities) with over 300 subject matter experts from across the federal government. Collectively, these working groups identified more than 280 impacts and vulnerabilities across the industrial base.

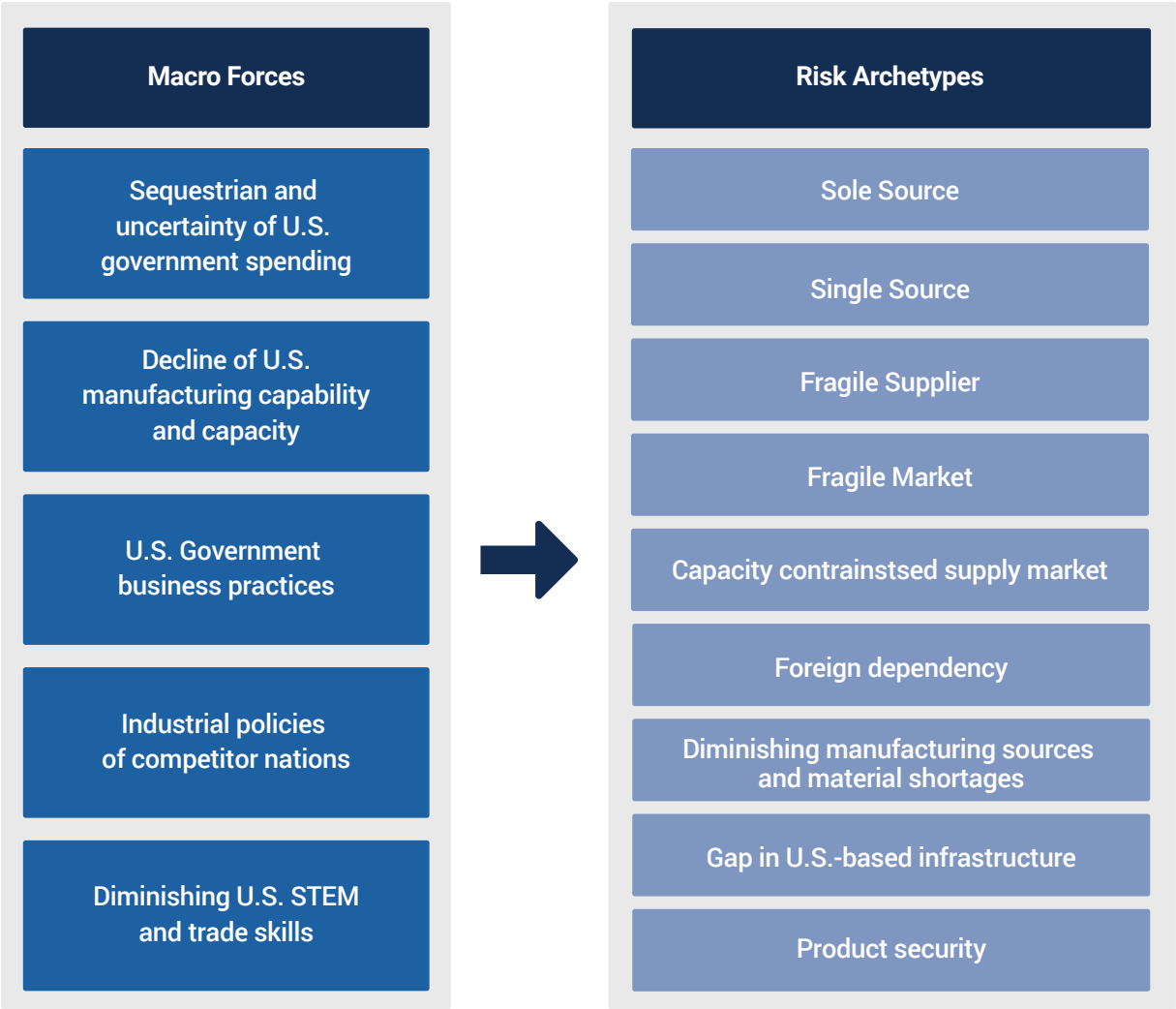
Following completion of the EO 13806 report, the sector working groups have continued to coordinate follow-on actions and risk mitigation activities for identified vulnerabilities. INDPOL serves as the hub for these working groups and helps to prioritize actions and investments across the industrial base. Updates to EO 13806 risk mitigation activities will be included as part of the annual industrial capabilities report for the associated fiscal year (Appendix A).

EO 13806 REPORT FINDINGS

The EO13806 review produced findings of critical and continued importance to the DIB.

- Macro forces have led to impacts primarily in the sub-tiers of the defense supply chain
- High levels of foreign dependence on competitor nations
- Workforce challenges across all sectors
- Continued movement of critical capabilities offshore in pursuit of competitive pricing and access to foreign markets
- The DoD can address many industrial base risks by:
  - Expanding direct investment in the lower tier of the industrial base through DPA Title III, Manufacturing Technology, and IBAS programs can address critical bottlenecks, support fragile suppliers, and mitigate single points-of-failure
  - Diversifying away from complete dependency on sources of supply in politically unstable countries who may cut off U.S. access to critical materials and technologies; diversification strategies may include reengineering, expanded use of the National Defense Stockpile program, or qualification of new suppliers
  - Working with allies and partners on joint industrial base challenges through the NTIB and similar structures
  - Modernizing the organic industrial base to ensure its ability to sustain fleets and meet contingency surge requirements

Figure 2: Macro Forces Map to Risk Archetypes



IMPLEMENTATION

The EO 13806 Report was broad and thorough. However, the industrial base is continuously evolving with the introduction of new threats and technologies. This review cannot be a one-time occurrence. As participating agencies work to correct identified vulnerabilities, they continue to assess the needs of emerging industries and technologies and their ability to provide for the needs of U.S. national defense now and into the future.

OFFICE OF TECHNOLOGY & MANUFACTURING INDUSTRIAL BASE (TMIB)

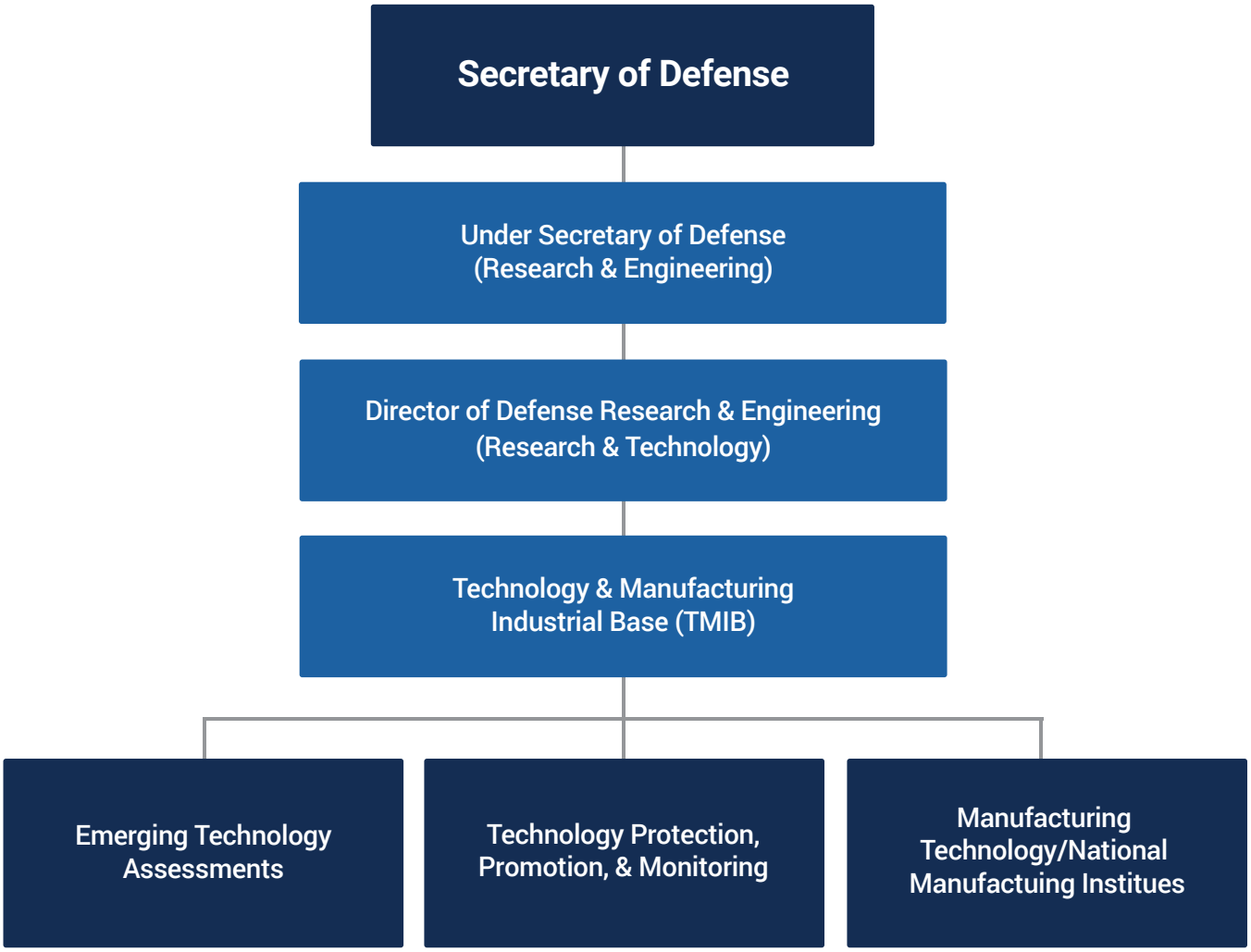
TECHNOLOGY & MANUFACTURING INDUSTRIAL BASE (TMIB)

TMIB Structure

When the Office of the Undersecretary of Defense (OUSD) for Acquisition, Technology, & Logistics split into OUSD Acquisition & Sustainment (A&S) and OUSD Research & Engineering (R&E), a number of authorities left the Office of Industrial Policy and were transferred to the Technology, Manufacturing, and Industrial Base (TMIB) office within the OUSD (R&E).

TMIB develops long-term strategies and employs mechanisms to retain the U.S. advantage in current and emerging technologies and the industrial base developing, manufacturing, and sustaining them. It also provides direct support for the development and execution of technology modernization activities and priorities. The office is divided in three main areas as shown in Figure 3.

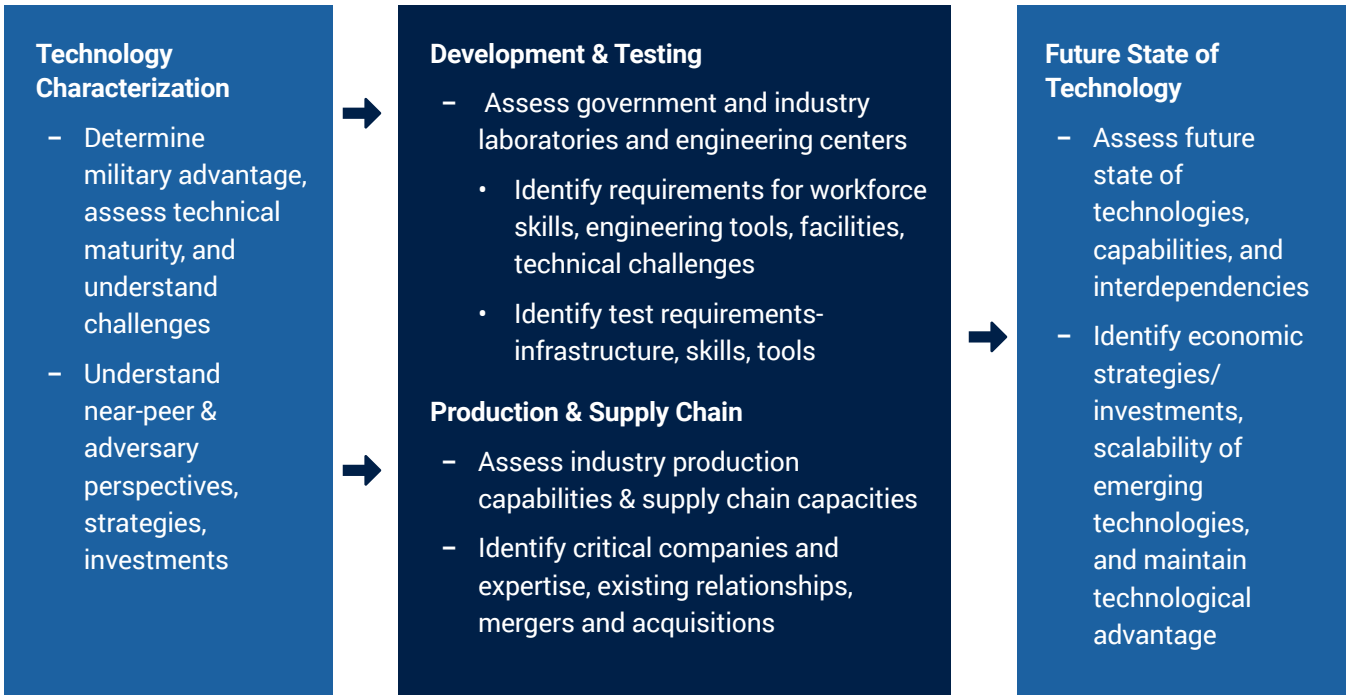
Figure 3: Technology, Manufacturing, and Industrial Base Organization Chart



TMIB Roles and Authorities

Emerging Technology Assessments: TMIB uses emerging technology assessments to translate technology requirements to manufacturing and industrial base requirements in order to identify industrial base issues, risks, and opportunities. TMIB created an assessment methodology that incorporates four types of studies to provide a full overview of the technology from a manufacturing and industrial base point of view. The results of the assessments are used to create technology and industrial base protection and promotion strategies.

Figure 4: Types of Technology and Manufacturing Studies



Technology Industrial Base Protection, Promotion, and Monitoring: This team facilitates the creation of strategies to protect and promote the industrial base by mitigating risks and exploiting opportunities identified in emergent technology assessments. TMIB will leverage DoD and Government-wide tools and initiatives to implement the strategies. TMIB uses data analytics to measure the success of mitigation and exploitation strategies, identify trends in the markets, and identify the need for additional assessments or changes in the strategies. As part of their portfolio, TMIB manages the OUSD(R&E) CFIUS, mergers and acquisitions, and export control license reviews. Their objective is to create balance between the protection of technology and promotion of the industrial base providing it. This balance will aid the Department's advancement of critical and emergent technologies while sustaining a healthy, resilient, and competitive industrial base.

Manufacturing Technology (ManTech) Program and National Manufacturing Innovation Institutes: TMIB manages the ManTech program and the National Manufacturing Innovation Institutes (MII). These programs are designed to help anticipate and close gaps in manufacturing capabilities for affordable, timely, and low-risk development, production, and sustainment of defense systems.

Programs & Authorities:

- 10 U.S. Code §2521 Manufacturing Technology Program (see page 150)
- National Manufacturing Innovation Institutes (MII) (see page 150)

DEFENSE INDUSTRY OUTLOOK

DEFENSE INDUSTRY OUTLOOK

Characteristics of the Market

The Aerospace and Defense sectors are Profitable and Expanding. The U.S. Aerospace and Defense (A&D) sector continues to outperform the broader U.S. equity market, appreciating at a similar rate as the technology sector. This implies that investors remain optimistic about the overall health, profitability, and long-term prospects of the sector (Chart 1). As a percentage of total Market Capitalization of the Dow Jones, the A&D Sector has remained between 2.0% - 2.5% for the last five years.

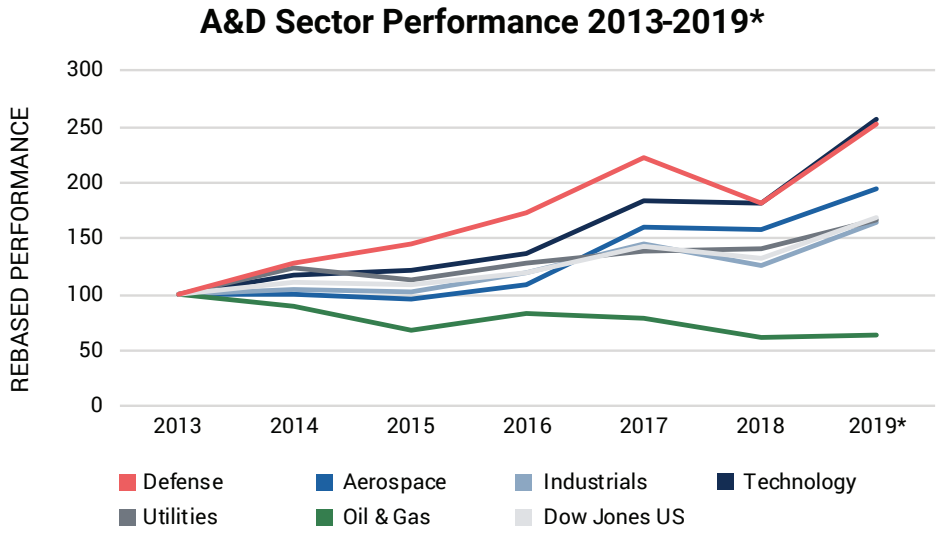


Chart 1: Stock Performance Trend by Market Sector [CY2013-CY2019] (2013 Rebase)
**2019 Performance as of December. Source: Thomson Reuters*

The U.S. Aerospace and Defense (A&D) sector continues to outperform the broader U.S. equity market, appreciating at a similar rate as the technology sector.

Supplier Assessment

The largest six prime defense suppliers (Lockheed Martin, Boeing, Northrop Grumman, Raytheon, General Dynamics, and BAE Systems) are known collectively as the "Big 6" and represented approximately 30% of all DoD prime obligations in 2018. They are also the largest companies globally by defense revenue.[10] The Big 6 thus provide a useful view with which to judge the overall health of the defense sector. The Big 6 are financially healthy and continue to expand in market share. They have also seen a general increase in revenue with a Market Capitalization Weighted Average Combined Annual Growth Rate (CAGR) of 2.6% from 2013-2018 (Chart 2).

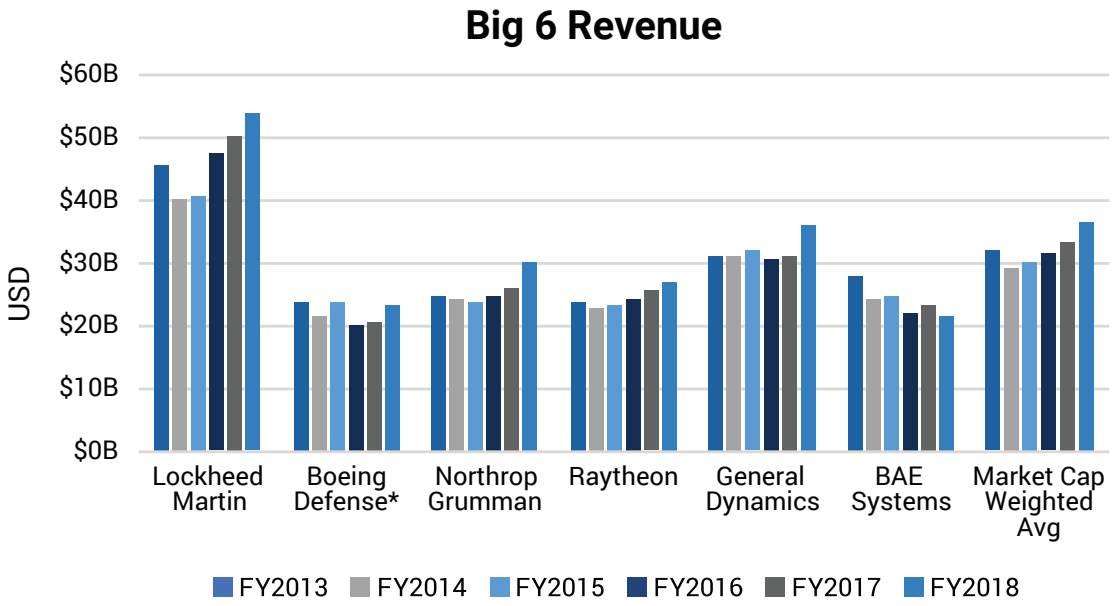


*Chart 2: Big 6 DoD Primes Annual Revenue [FY2013-FY2018] *Only Revenue for Boeing Defense Business Segment Displayed Source: Thomson Reuters*

The Big 6 are also profitable, showing positive Earnings Before Interest, Tax, Depreciation, and Amortization (EBITDA) as well as an overall increase in margins over the last five years (Chart 3). Major defense suppliers have seen growing demand for their products and services, driving higher sales and greater scale helping to reduce costs and boost competitiveness.

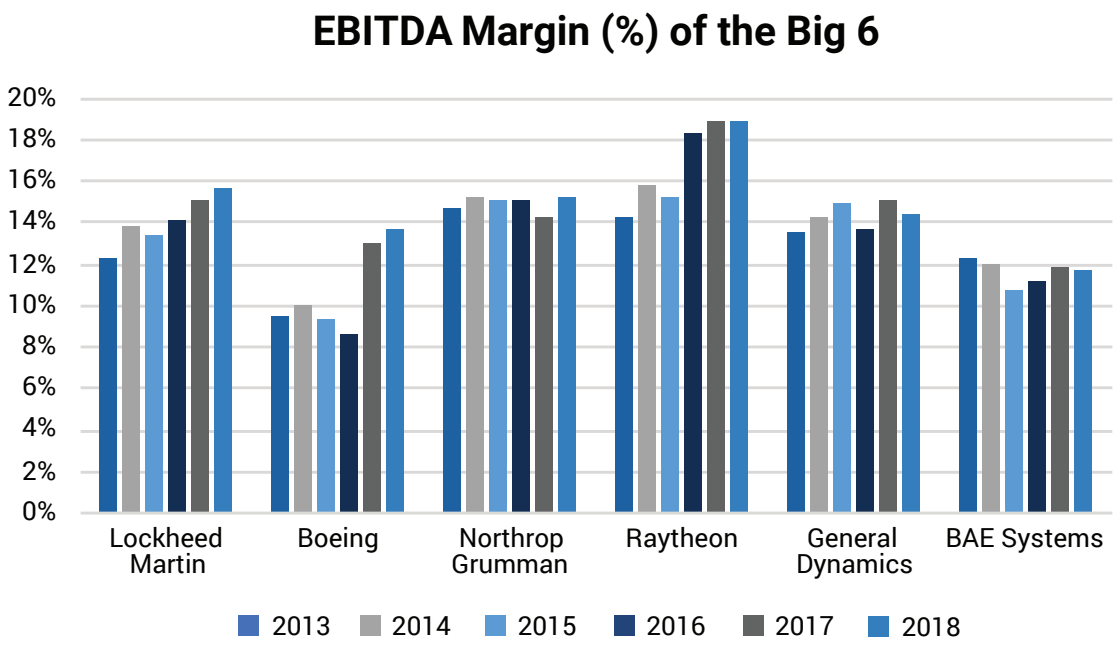


Chart 3: Big 6 DoD Prime EBITDA Margin [FY2013-FY2018]
Source: Thomson Reuters

However, to maintain top line growth and mitigate the cyclicality of U.S. defense spending some firms will continue to diversify their customer base and pursue international and non-defense customers. Historically the Big 6 trended toward a rise in non-defense revenue. In 2018 the share of non-defense business revenue decreased primarily due to a realignment of business segments by Boeing (Chart 4).[11]

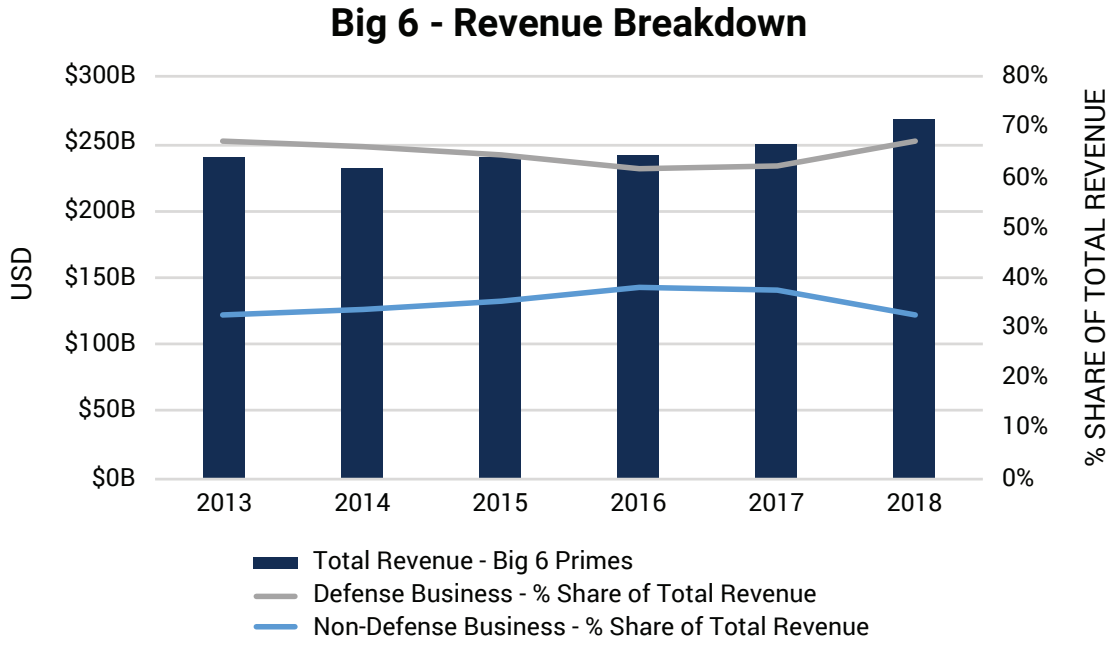


Chart 4: Defense Vs Non-Defense Revenue for Big 6 Primes [CY2013-CY2018]
Source: Thomson Reuters & Defense News Top 100

Over the last several years, the Big 6 have maintained a relatively stable share of sales coming from outside the United States (Chart 5). Despite minimal change as a percent of total revenue, international sales have increased at an annualized rate of 2.9% over the last five years.

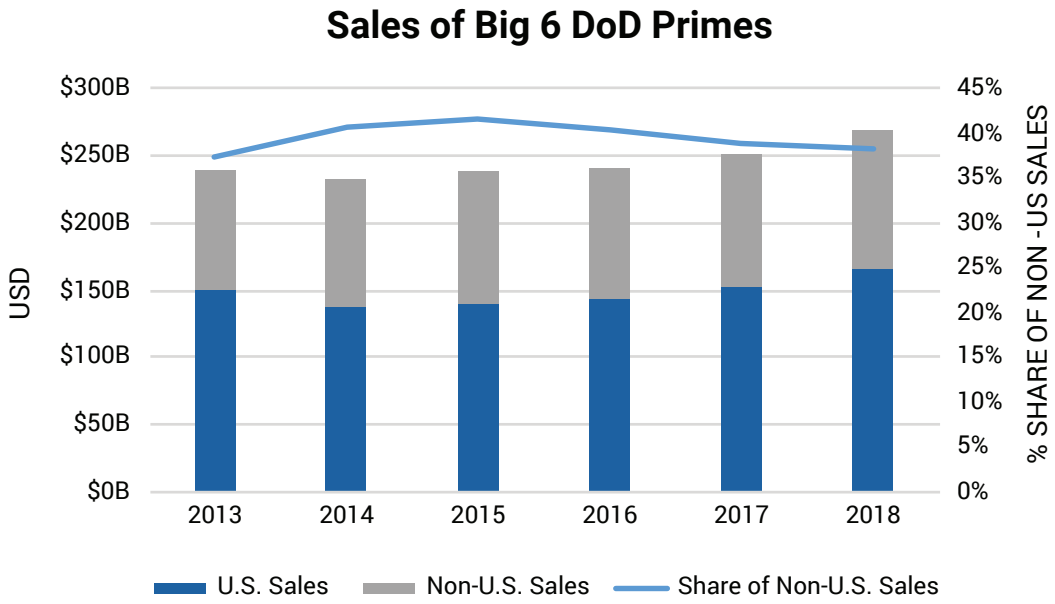


Chart 5: Defense Vs Non-Defense Revenue for Big 6 Primes [CY2013-CY2018]
Source: Thomson Reuters & Defense News Top 100

The Big 6 continue to focus their capital deployment on shareholder return (5 Year CAGR: 11.4%). However, investments hit a six year high in 2018 at $33.9 billion with firms investing largely in acquisition of subsidiaries, research and development, and capital expenditures (Chart 6).

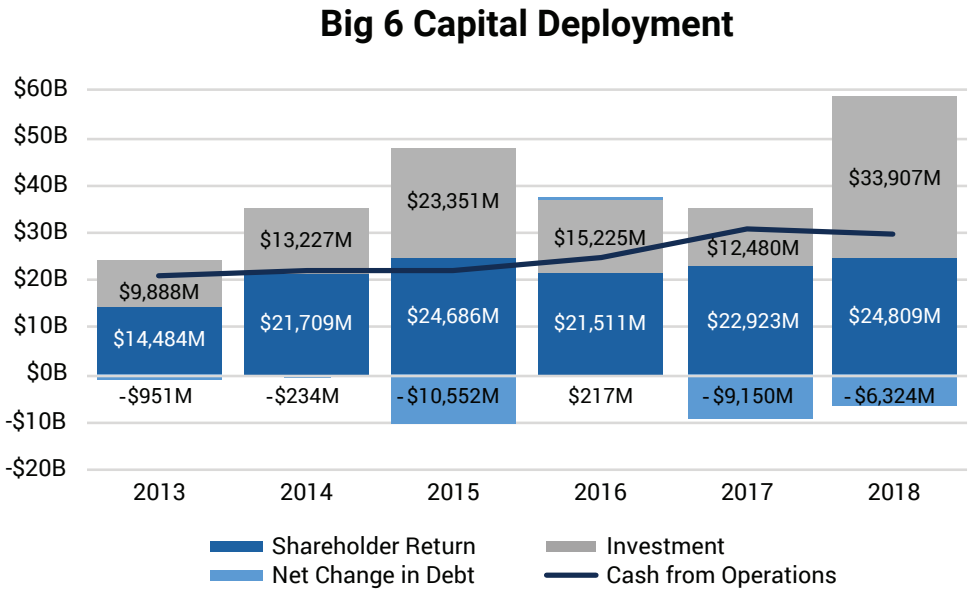


Chart 6 Capital Deployment of Big 6 Primes [CY2012-CY2018]
Investment: Cash for Acquisition of Subsidiaries, R&D Expense, CAPEX
Shareholder Return: Dividends Paid, Decrease in Capital Stocks
Net Change in Debt: Proceeds from Repayment of Borrowings
Source: Bloomberg. Source: Thomson Reuters

Defense Sector and Department of Defense Investment

Globally, A&D companies are among the lowest R&D spenders compared to other critical sectors. The Technology sector primes known as the FAANG companies (Facebook, Amazon, Apple, Netflix, and Google) spend on average 10% of their sales on R&D each year. The Big 6 have spent on average 3% of their sales on R&D each year. A rebased trend plot shows that expenditures on R&D by the Big 6 closely track DoD Research, Development, Testing, and Engineering (RDT&E) spending (Chart 7). This implies that defense suppliers rely on the guidance provided by DoD to drive development of newer technologies and capabilities.

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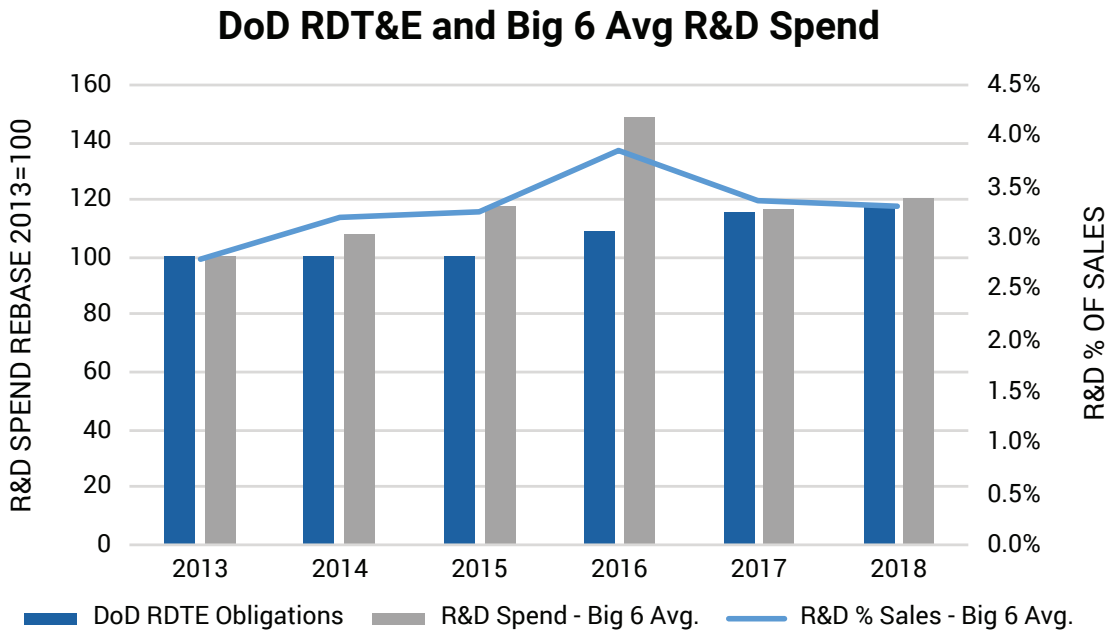


Chart 7: DoD RDT&E Obligations and Big 6 Average R&D Spending (Rebased 2013) [FY2013-FY218]
Source: Thomson Reuters and FPDS

DoD Spending Trends

While the DoD is a significant purchaser of products and goods, annual obligations also include a significant amount of spending related to services. The development of manufactured goods as well as general support for the department results in a heavy reliance on services. Obligations have maintained a near even split between products and services (when R&D is included with services) since FY 2013 (Chart 8).

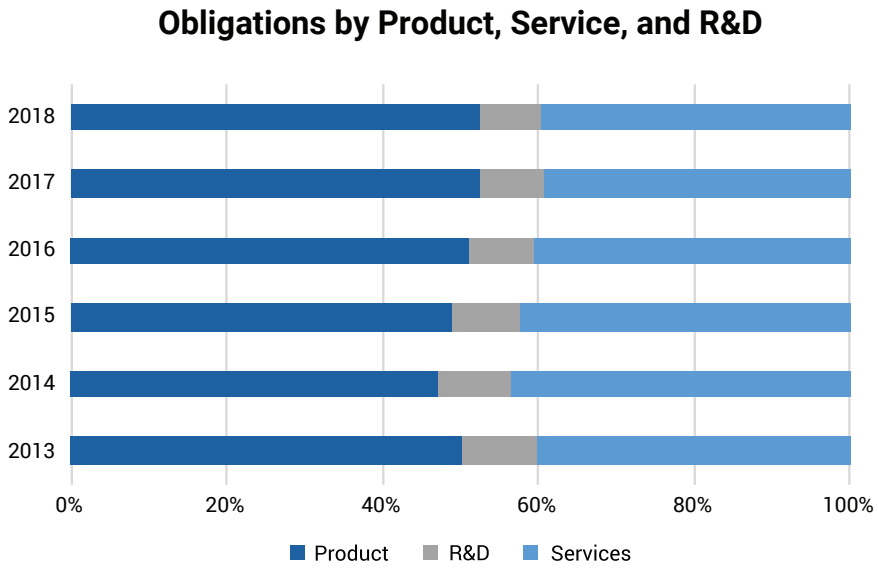


Chart 8: Obligations by Product, Service, and R&D [FY2013-FY2018]
Source: FPDS

DoD obligations also remain concentrated within a select number of suppliers. The Big 6 DoD contractors accounted for nearly a third of all obligations in 2018. Furthermore, nearly half of all obligations between 2013 and 2018 were awarded to the top 25 DoD suppliers (Big 6 Included).

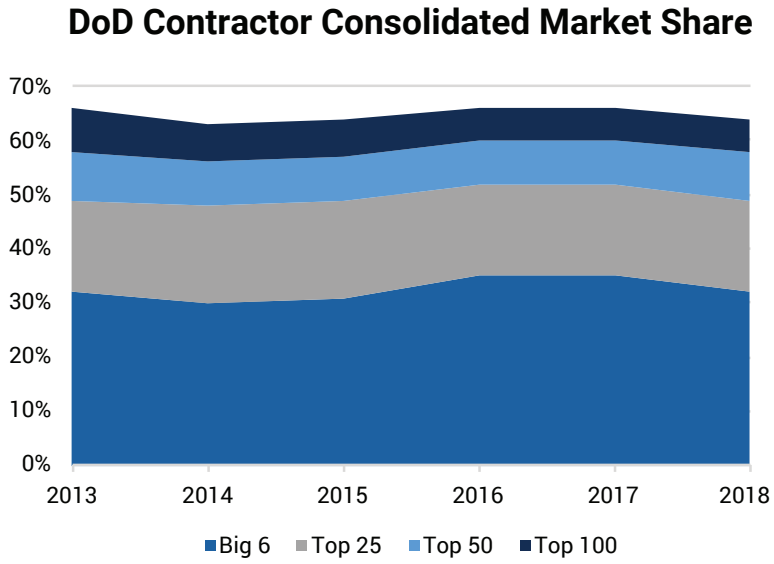
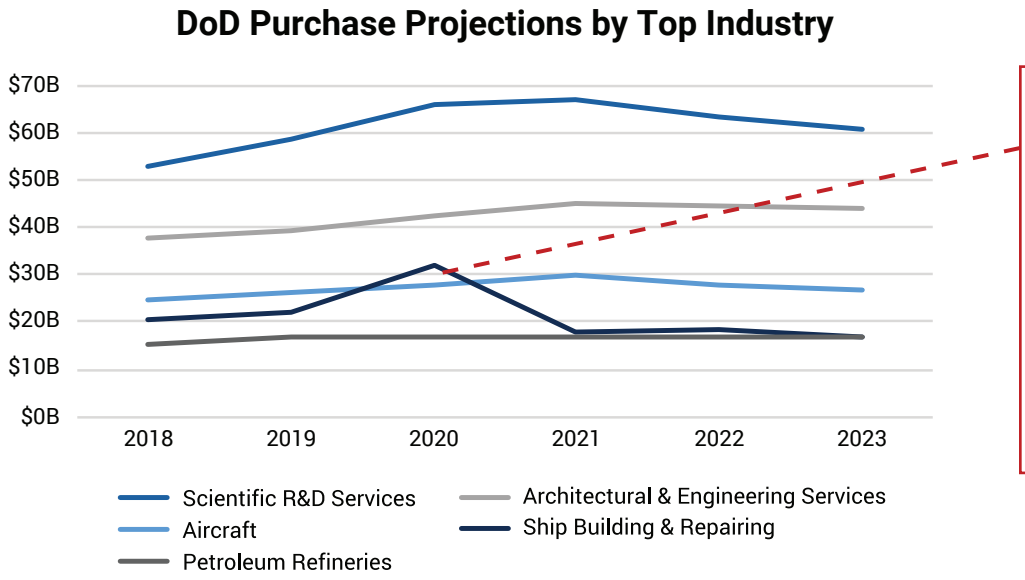


Chart 9: Consolidation of DoD Prime Contract Obligations [FY2013-FY2018]
Source: FPDS

Top US Industries Influenced by Department of Defense Spending

The Defense Employment and Purchases Projection System (DEPPS) is an annual publication that analyzes and forecasts the distribution of defense spending among U.S. industries and regions.[12] According DEPPS, a significant share of purchases made directly by the DoD flow to the following five industries: Scientific and R&D Services, Architectural and Engineering Services, Aircraft, Ship Building and Repair, and Petroleum Refineries. The projections displayed in (Chart 10) show a continued emphasis on these industries within the Defense Budget.



According to the Congressional Budget Office's "Analysis of the Navy's Fiscal Year 2020 Shipbuilding Plan" the current shipbuilding cycle will peak in 2020 with the budget reducing until 2024 when it will once again climb to facilitate the addition of 304 new ship orders to be fulfilled by 2049.

Chart 10:Total Defense Demands by Commodity Projection Top 5 Industries [CY2018-CY2023]
Source: DEPPS 2019 Projected Defense Purchases

The DoD also requires imports to fulfill purchases for crucial defense industries (Chart 11) such as Broadcast and Wireless Communications Equipment, Semiconductors, and other Electronic Components which reflects the global supply chain upon which critical defense technologies are built.

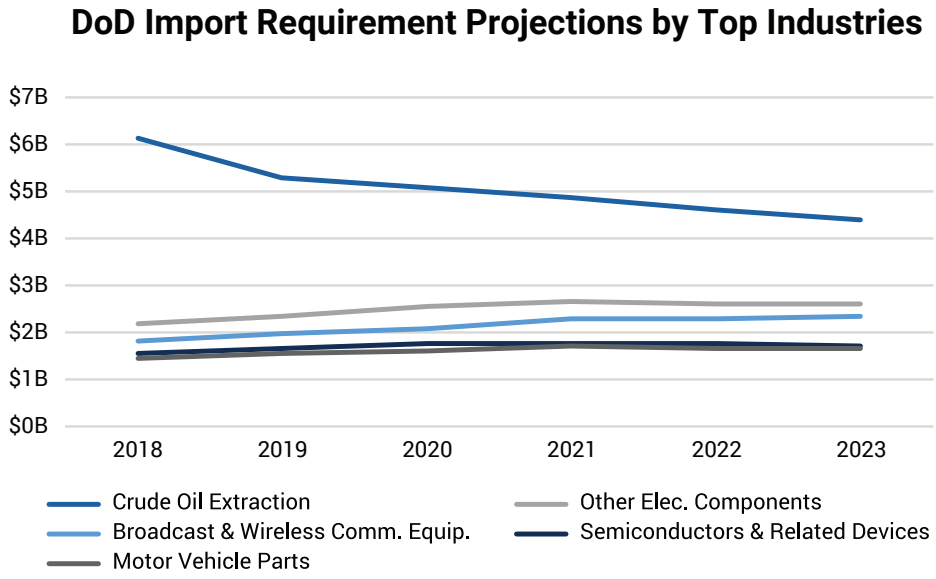


Chart 11 DoD Import Requirements by Commodity Projection Top 5 Industries [CY2018-CY2023]
Source: DEPPS 2019 Projected Defense Purchases

US Position in Global Defense Markets

Global Defense Markets

Global military spending continues to grow, expanding from $1.7 trillion in 2017 to $1.8 trillion in 2018. The United States maintains its position as the largest purchaser of military goods and services in the world. Over the last decade China has emerged as the second largest purchaser of military goods and services, nearly tripling its spending from $86B in 2008 to $250B in 2018. Beyond China and the United States, defense spending grew in the rest of the world from $783 billion in 2008 to $884 billion in 2018 led by Saudi Arabia, Russia, India, France, United Kingdom, Germany, Japan, and South Korea (Chart 12).

Global military spending continues to grow, expanding from **$1.7 trillion** in 2017 to **$1.8 trillion** in 2018

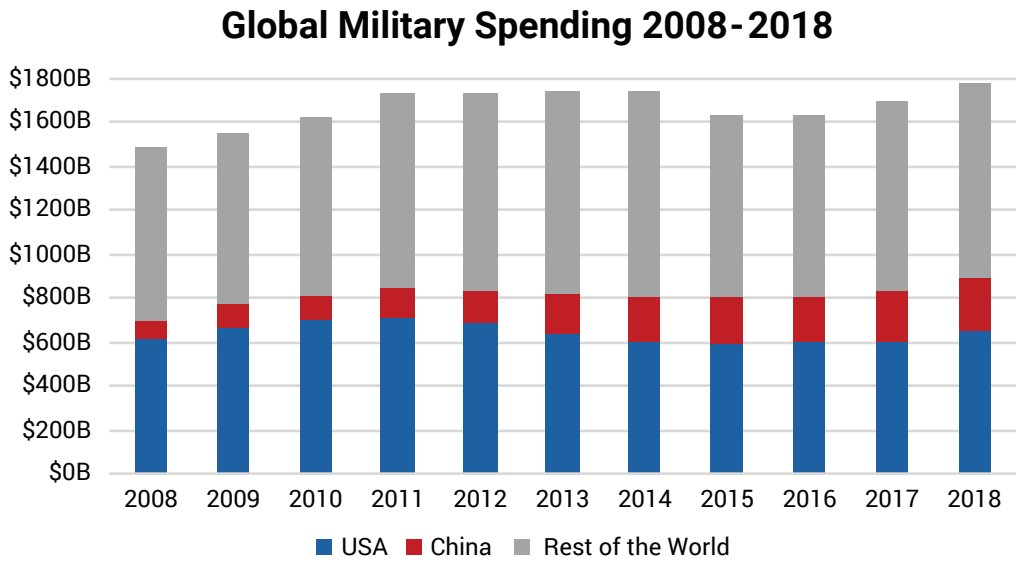


Chart 12: Global Military Spending (2018 Dollars) [CY2008-CY2018]
Source: SIPRI Military Expenditure Database

U.S. defense spending fluctuated over the last decade, rising 14.5% from 2008-2011 then plummeting 16.2% from 2011-2015 and finally rising again 8.8% to its 2018 level of $648.8B. By contrast China has steadily increased its defense spending at an annualized rate of 11.2% for the past decade. The Chinese share of global military spending has risen from 5.8% in 2008 to 14.0% in 2018 while the U.S. share of global military spending has fallen from 41.7% in 2008 to 36.4% in 2018 (Chart 13).

Over the last decade, China has emerged as the second largest purchaser of military goods and services, nearly tripling its spending from $86 billion in 2008 to $250 billion in 2018.

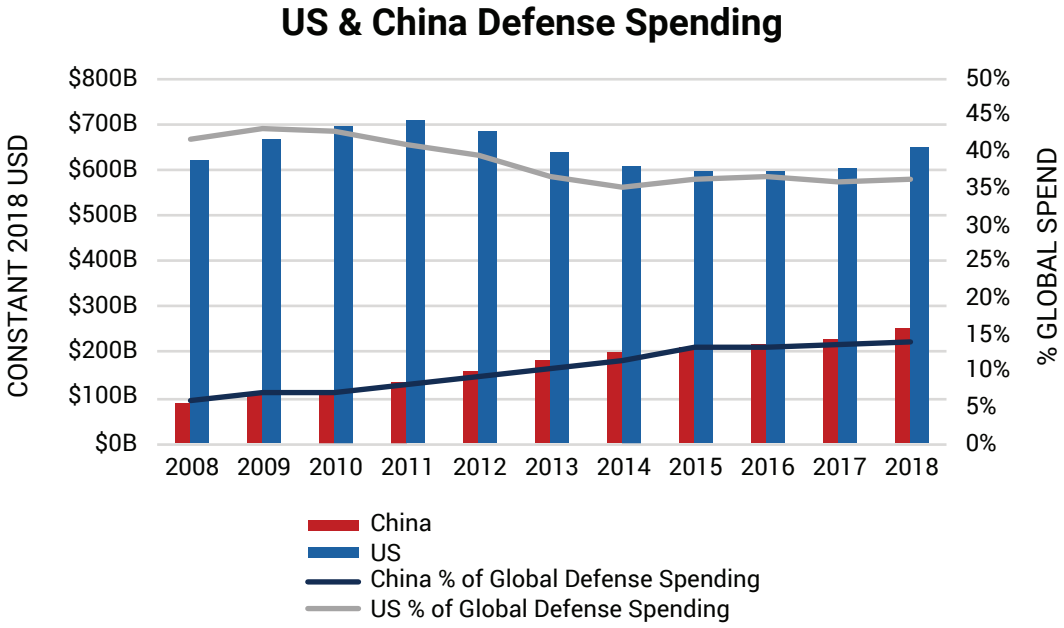


Chart 13: U.S. & China Defense Spending and % of Global Defense Spending (2018 Dollars) [CY2008-CY2018]
Source: SIPRI Military Expenditure Database

Global Arms Trade

The United States and Russia remain the two largest exporters of arms in the World (Chart 14). The United States increased its market share of Global Arms Exports from 28.2% in 2008 to 38.1% in 2018 (10 Year CAGR: 4.4%). Russian arms exports have remained relatively flat, contracting from 25.8% in 2008 to 23.2% in 2018 (10 Year CAGR: 0.2%). Finally, China's global arms exports market share has remained relatively small despite its significant increase in defense spending, growing slightly from 2.7% in 2008 to 3.8% in 2018.[13]

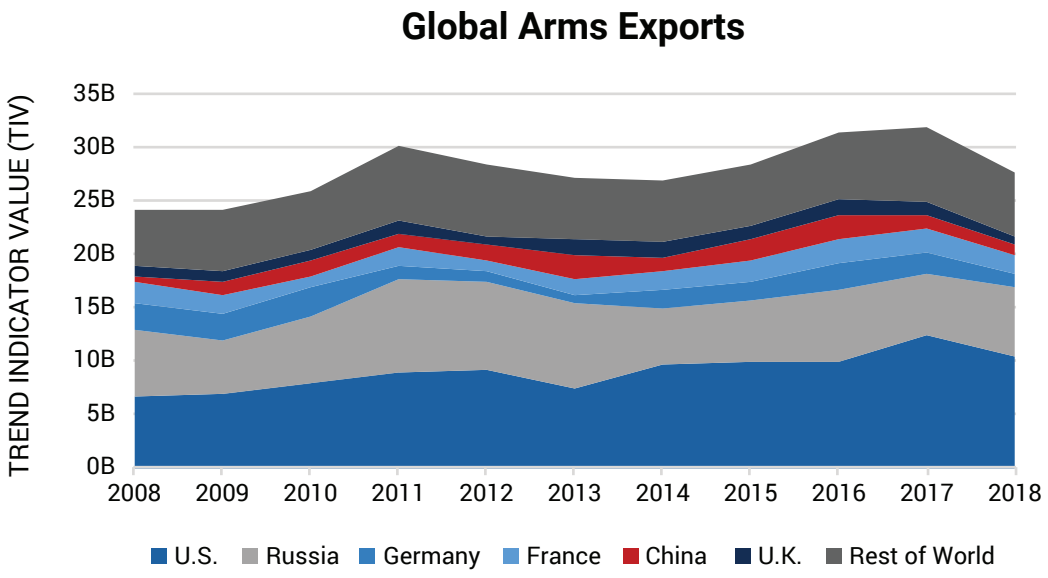
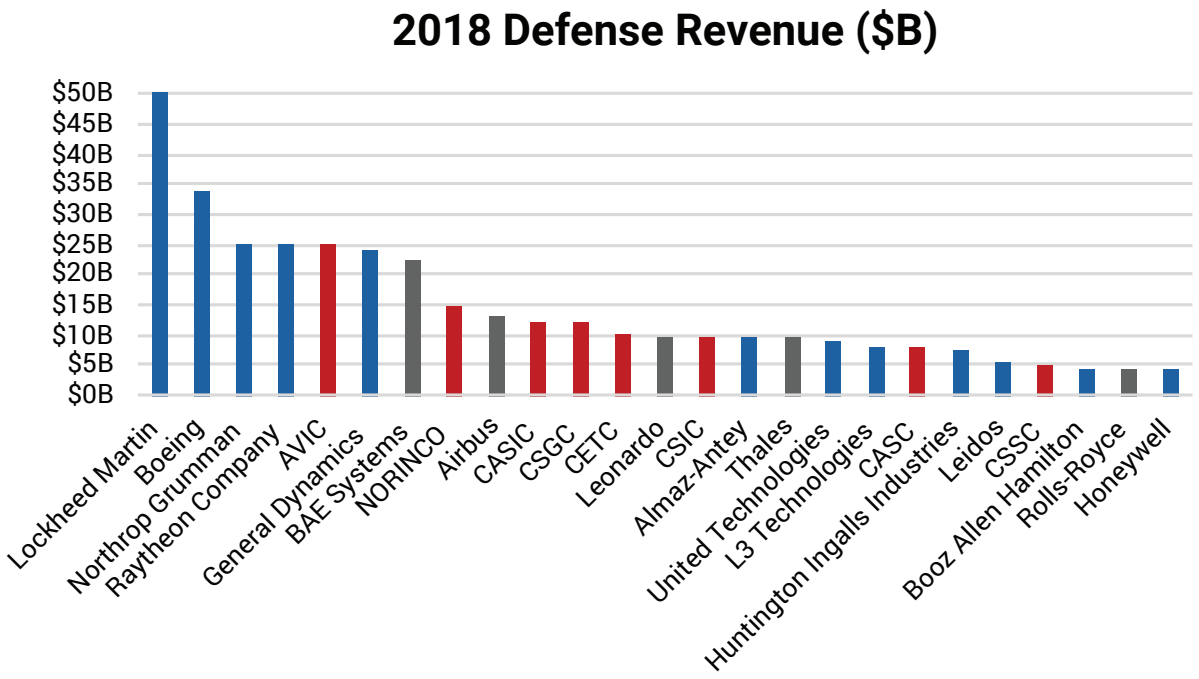


Chart 14: Global Arms Exports in Trend Indicator Value [CY2008-CY2018]
Source: SIPRI Arms Transfers Database

China has emerged as a major defense manufacturer with Chinese companies listed for the first time ever on the 2019 Defense News Top 100 list of the largest global companies by defense revenue. All eight of the companies on the list fall within the largest 25 international defense firms (Chart 15). These eight Chinese defense manufacturers had a combined growth of 3.5% YoY in 2018.



AVIC: Aviation Industry Corporation of China
NORINCO: China North Industries Group Corporation
CASIC: China Aerospace Science & Industry Corporation
CSGC: China South Industries Group Corporation
CETC: China Electronics Technology Group
CSIC: China Shipbuilding Industry Corporation
CASC: China Aerospace Science & Technology Corporation
CSSC: China State Shipbuilding Corporation

Chart 15: Top 25 Global Defense Companies by Arms Sales [CY2018]
Source: Defense News Top 100

Global Defense Investment

The United States continues to lead the world in Gross Domestic Spending on R&D[14], however China is rapidly closing the gap with the United States (Chart 16).

The United States continues to lead the world in GDP spending on R&D, however, China is rapidly closing the gap.

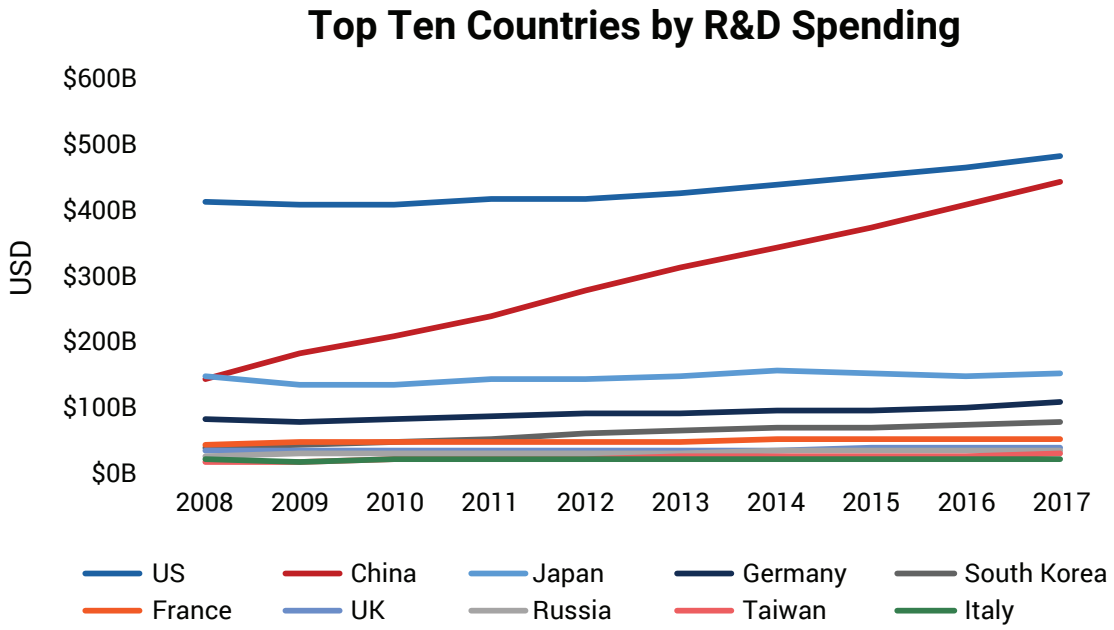


Chart 16: Top Ten Countries by Gross Domestic Spending on R&D [2008-2017]
Source: OECD (R&D Data is Released on a 2-Year Lag)

In the March 2018 Section 301 report published by the Office of the United States Trade Representative, China was found to utilize investments within the United States to obtain essential intellectual property in key industries. According to the report, "Chinese firms invest in the United States to learn from U.S. firms, not the other way around. This policy harms innovation by essentially transferring technologies from efficient and productive firms in the United States to less innovative and less productive firms in China."

The growing number of Chinese investments targeted at specific U.S. critical industries illustrates China's strategy of gaining advantage through U.S. innovation (Chart 17). The recent overall reduction in targeted deals for 2017 and 2018, in part, reflects the efforts on the part of the United States to increase scrutiny through new legislation such as the Foreign Investment Risk Review Modernization Act of 2018 and the Export Control Reform Act of 2018.

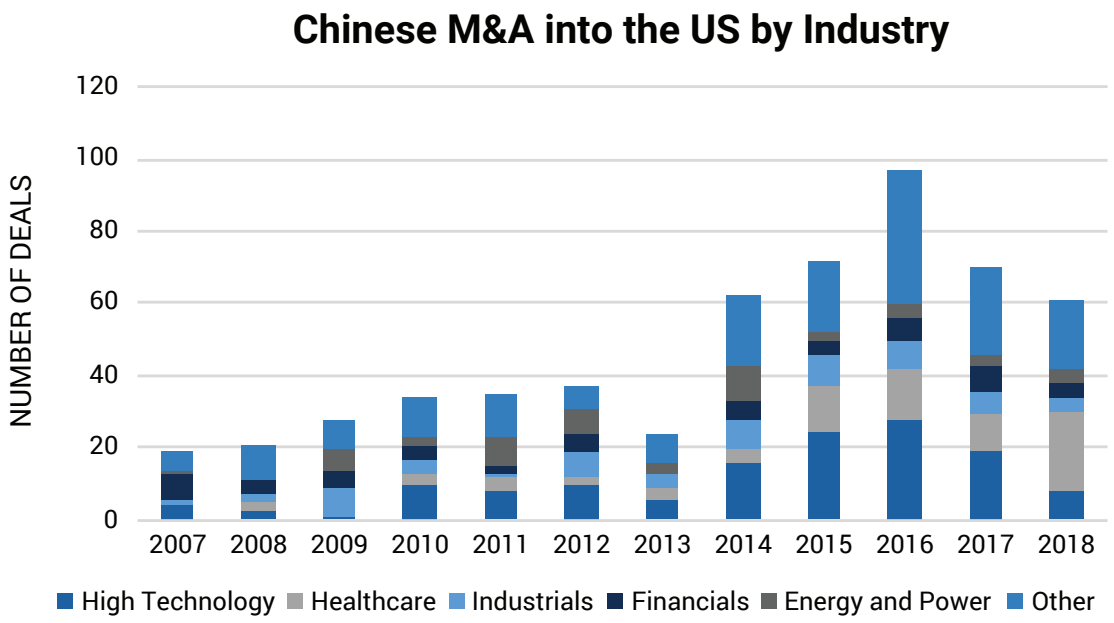


Chart 17: Chinese M&A Activity Into The United States [CY2007-CY2018]
Source: DIBNow

SECTOR ASSESSMENTS

AIRCRAFT

Sector Overview

The aircraft sector is categorized into three subsectors: fixed-wing aircraft, rotary-wing aircraft and unmanned aircraft systems (UAS).

Fixed-wing aircraft

Include fighters, bombers, cargo, transportation, and any manned aircraft that use a set of stationary wings to generate lift and fly.

Rotary-wing aircraft

Use lift generated by rotor blades revolving around a mast. These aircraft are designed to operate in harsh battlefield environments, requiring robust, advanced capabilities and systems.

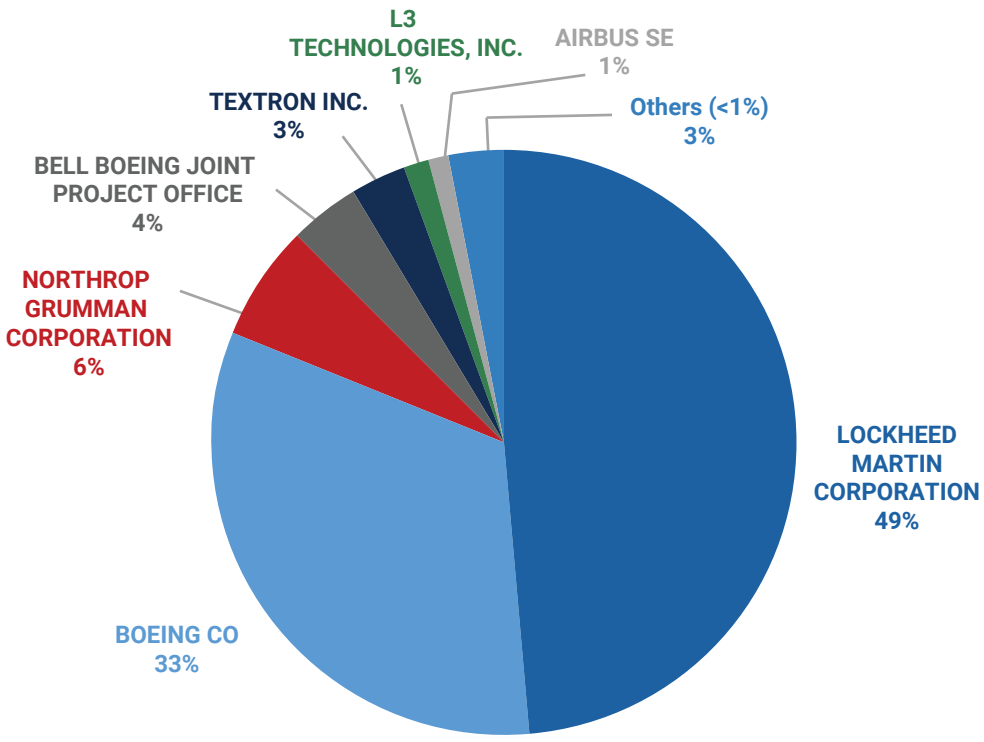
UAS

Can be either fixed-wing or rotary-wing aircraft but for assessment purposes, INDPOL treats UAS as a separate subsector. UAS include the necessary components, equipment, network, and personnel to control an unmanned aircraft. The unmanned aircraft systems' industry ranges from bird-size to 100+ foot wingspans. The industry supporting unmanned aircraft system production is wide-ranging and in a state of rapid transition, as civil end-users overtake military-specific users, with a significant shift in market development and production of small to medium-sized platforms (Groups I-III) from U.S. sources to those based in China.

Table 2: Aircraft Subsectors

SUBSECTOR	MANUFACTURER	AIRCRAFT TYPE
Fixed-Wing	Boeing	B-1 Lancer, F/A-18 Hornet/Super Hornet, P-8 Poseidon, EA-18G Growler, F-15 Eagle, E-3 Sentry, E-6 Mercury, A-10 Warthog, B-52 Stratofortress, AV-8B Harrier II, EA-6B Prowler, E-4 Advanced Airborne Command Post (AACP)
	Lockheed Martin	F-16 Falcon, F-22 Raptor, F-35A/B/C Lightning II, U-2
	Northrop Grumman	E-2D Advanced Hawkeye, B-2 Spirit, E-8 Joint STARS, B-21 Raider
	Various	P-3 Orion, EP-3 ARIES, EC-130H Compass Call
Rotary-Wing	Airbus	UH-72A Lakota
	Bell Boeing	CV/V-22 Osprey
	Bell Textron	UH-1Y Venom, AH-1Z Viper
	Boeing	AH-64 Apache, H-47 Chinook, MH-139
	LM-Sikorsky	CH-53 Sea Stallion/Super Stallion, MH-53 Pave Low, HH-60 Pave Hawk, MH-60 Knighthawk, UH-60 Black hawk, VH-3D Sea King, VH-60N White Hawk, VH-92
UAS	Aerovironment	RQ-11 Raven, RQ-20 Puma
	Boeing	RQ-21 Blackjack
	General Atomics	MQ-1 Predator, MQ-9 Reaper
	Northrop Grumman	MQ-4 Triton, MQ-8 Fire Scout, RQ-4 Global Hawk
	Textron	RQ-7B Shadow

Figure 5: Aircraft Sector Market Share



Major Risks & Issues

All three aircraft sub-sectors face challenges, including long product/system development timelines, high development and qualification costs, and production limitations. During the 1990s, a dramatic decline in aircraft procurement led to consolidation of prime suppliers in the sector. Consolidation continues today and has expanded into the sub-tiers of the supply chain, creating additional risks for single or sole source vendors. In addition, the sector is experiencing a shortage of workers with critical hardware and software design capabilities due to large retirement populations, limited knowledge transfer opportunities, and skyrocketing demand for software engineers outstripping supply in multiple product line sectors.

Aircraft Design and Engineering Human Capital

Defense-unique design skills are necessary to spur innovation and enable revolutionary platform development. Current modernization programs help sustain important capabilities but do not provide enough opportunities to maintain skills to dominate major design and next generation development work. With the end of several advanced development programs approaching, an absence of new requirements in the next five to seven years, and retirees leaving gaps in critical experience, the industrial base workforce faces a shortage of critical design capabilities.

Maintaining the capability to innovate becomes increasingly challenging as skilled aerospace, mechanical, electrical, and software engineers leave the workforce—taking with them critical knowledge for the development of next-generation technologies.

Another endemic workforce weakness experienced across numerous sectors is limited investment by government and industry to maintain innovation and design skill development due to a lack of consistent R&D funds.

Each subsector faces distinct challenges. The fixed-wing sector will not see a new program start until the F-X and F/A-XX programs begin to take shape, resulting in limited opportunities to keep design teams active for next generation tactical air support fighters. Compounding this issue, most current tactical air support design engineering teams have employees at, or near, retirement age. Industry is working closely with the Defense Advanced Research Projects Agency on the Penetrating Counter Air and Next Generation Air Dominance programs. These efforts will set the stage for next generation fighter aircraft capabilities, provide current teams with new design work, and provide older employees the opportunity to transfer unique skills and knowledge to the next generation.

In fourth generation fighters, software made up about 15% of the total engineering of the aircraft. In fifth generation fighters, software not accounts for over 40% of the engineering of the aircraft.

Software skills are also a critical issue for the aircraft sector. In fourth generation fighters, software made up about 15% of the total engineering of the aircraft. In fifth generation fighters, software now accounts for over 40% of the engineering of the aircraft. It is becoming increasing difficult to hire enough skilled, cleared, and qualified software engineers. As the complexity of aircraft software grows, it will become even more important for the sector to hire highly skilled software engineers.

Large, Complex Alloy Castings

There are currently four suppliers with the capability to manufacture large, complex, single pour aluminum and magnesium sand castings. These suppliers face perpetual financial risk, and experience bankruptcy threats and mergers that mirror fluctuations in DoD procurement. The single qualified source for upper, intermediate, and sump housing for a Marine Corps heavy lift platform has experienced quality issues and recently underwent and emerged from bankruptcy proceedings. Without a qualified source for these castings, the program will face delays, potentially impeding the U.S. ability to field heavy lift support to expeditionary forces.

Aircraft Fuel Cell (Bladder)

Only two qualified sources exist for DoD fuel cells, also referred to as fuel “bladders”. Many DoD programs rely on a single source due to cost and schedule impacts from qualifying a second supplier, which involves crashworthiness and ballistic penetration testing. Nearly three-quarters of current fuel cell demand is driven by sustainment requirements with a direct impact on warfighter readiness. There are a few similar issues and risks among current fuel cell suppliers. Fuel cell suppliers rely on a manual, labor-intensive production process that often results in many hours spent on production rework, or results in material waste when scrapping parts that cannot be reworked. Workforce availability is also an issue for both production facilities, which could make it difficult to maintain or increase production capacity.

Budget Considerations

Readiness funding increases in FY2017–FY2019 addressed many shortfalls. The FY2020 budget request prioritized modernization, and RDT&E funding requests increase by 9.4 percent over FY2019. The DoD has programs in place to modernize individual fleets, but delays in modernization programs will force aging aircraft fleets to remain in service longer than originally anticipated. For example, the B-21 program is in development with budget demands rising from $2.3 billion in FY2019 to $3 billion in FY2020.

Notable Developments

Mergers and Acquisitions

United Technologies (UTC) received the final regulatory approval to acquire Rockwell Collins in November 2018, which was one of the largest acquisitions in the history of the aerospace industrial base. UTC's aerospace portfolio will now include Rockwell Collins' avionics manufacturing, defense business and interiors unit.

Table 3: FY2019 Mergers & Acquisitions

ACQUISITION/MERGER	EST. VALUE (USD)	COMPLETION DATE
UTC acquires Rockwell Collins	$30B	Nov-18
Elbit Systems Ltd. Acquires Universal Avionics Systems Corporation	$120M	Nov-18
Parker Hannifin Corp. acquires Lord Corporation	$3.68M	Oct-19
Sekisui Chemical Group acquires AIM Aerospace	$510M	Q4 2019
United Technologies Corporation merges with Raytheon Company	TBD	Mid-2020

A proposed merger deal between UTC and Raytheon is still pending and the transaction will likely close, if approved, by mid-2020. The combined company will leverage the combined knowledge base of approximately 60,000 engineers. The newly merged company is anticipating spending approximately $8 billion annually on research and development.

Foreign Military Sales

In FY2019, the biggest foreign military sales (FMS) customer was Taiwan. Sales to Taiwan amounted to $10.7B, including an $8B request for 66 F-16 aircraft. In September 2019, State Department also approved the sale of 32 F-35 Joint Strike Fighters (JSF) to Poland for $6.5B. This FMS agreement will partially offset the cancelled delivery plan of 100 F-35s to Turkey. FMS provides additional opportunities for work to U.S. companies, helping to keep production lines warm during times of limited U.S. procurement.

Table 4: FY2019 Foreign Military Sales (FMS) Agreements

Foreign Military Sales (FMS) Agreements				
	YEAR	COUNTRY	VALUE	PROGRAM/SYSTEM
Lockheed Martin	2019	Poland	$6.5B	32 F-35 Joint Strike Fighter Conventional Take Off and Landing aircraft with additional support equipment and replacement/ spare parts
	2019	Taipei Economic and Cultural Representative Office	$8B	66 F-16C/D Block 70 aircraft with additional support equipment
	2019	Bulgaria	$1.7B	8 F-16C/D Block 70/72 aircraft with additional support equipment and replacement/ spare parts
	2019	Morocco	$3.8B	25 F-16C/D Block 72 aircraft with additional support equipment and replacement/ spare parts
Boeing/ Lockheed Martin/ GE/ Thales/ Longbow/ Raytheon	2019	Qatar	$3.0B	24 AH-64E Apache Attack helicopters with additional support equipment and replacement / spare parts
Lockheed Martin/GE	2019	Czech Republic	$0.8B	12 UH-60M Black Hawk helicopters with additional support equipment and replacement/ spare parts

Sector Outlook

As current conflicts wind down, there will be a reduction in planned military buys and increased focus on survivable systems capable of operating in an anti-access area denial or defended airspace. However, the rotary-wing budget may likely increase due to programs involving Future Vertical Lift requirements.

Air Force is planning to procure only 12 MQ-9 Reapers in FY2020, leaving the unmanned element of its aircraft inventory at six percent of the force. This slowed growth is driven partially by uncertainty regarding how to adapt unmanned platforms for the non-permissive environments of great power conflicts.

The global military UAS market is estimated at $9.6B in 2019 and is projected to reach $13.2B by 2025, at a compound annual growth rate (CAGR) of 6.59% from 2019 to 2025.[15]

CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR DEFENSE

Sector Overview

The Chemical, Biological, Radiological, and Nuclear Defense (CBRND) Sector provides capabilities through the integration of science, engineering, testing, and logistics to field products that provide protection from threats and attacks. The sector is composed of commercial and organic industries which provide an aggregation of capabilities needed to develop and provide technical products in the areas of:

- Medical countermeasures to address CBRN and emerging infectious diseases
- Protection for the Warfighter through respirators, masks, decontamination kits, etc.
- Contamination avoidance through development and use of sensors, monitors, and detectors
- Guardian systems to provide support for first responders, and
- Information systems that consist of integrated early warning, hazard prediction models, consequence management, and decision support tools

The DoD Chemical and Biological Defense Program's (CBDP) mission is to enable the Warfighter and first responders to deter, prevent, protect, mitigate, respond, and recover from CBRN threats and effects as part of a layered, integrated defense. To support this mission, the CBRND industrial base sustains the capabilities needed to support the CBDP's three strategic readiness goals:

1. Equip the force to successfully conduct military operations to prevent, protect, and respond to CBRN threats;
2. Develop new capabilities to counter emerging CBRN threats; and
3. Maintain industrial capabilities to achieve National Security Strategy requirements.

The 2017 National Security Strategy indicates the importance of the sector as it provides critical capabilities to counter hostile states and terrorist groups increasingly trying to acquire nuclear, chemical, radiological, and biological weapons.

Major Risks & Issues

The CBRND industrial base supports a niche market heavily dependent on DoD procurement for sustainability and technology development. It is also highly dependent on single and sole source manufacturers, which is common in industrial base sectors that are smaller and highly technical.

In many scenarios, this industrial capability constraint can be directly attributed to United States Government procurement practices, inconsistent funding and demand signals, and eroding manufacturing capabilities and associated workforce shortfalls. However, the primary constraint rests in DoD barriers which restrict entry to new suppliers and present qualification challenges that limit competition within the base. A capacity-constrained supply market and the erosion of U.S.-based infrastructure create gaps in the sector that may lead to limited or non-existent domestic industrial capabilities to support the NDS.

Notable Developments

FY2019 appropriations supported the procurement of critical CBRND equipment needed to increase unit and individual survivability by supporting Army mission requirements in four primary categories: Collective Protection, Contamination Avoidance, Decontamination, and Radiological Detection System.

- The Contamination Avoidance program includes systems that provide detection, identification, collection, and reporting of CBRN hazards. Contamination avoidance appropriations include funding for Integrated Early Warning (IEW) technology, and the procurement of CBRN Robotics, MRDS, PINS, RAZORS, and HAPSITE systems.
- The Radiological Detection System currently consists of the AN/PDR-77 Radiac Set, which provides the Warfighter with the capability to measure alpha, beta, gamma, and low energy x-rays for nuclear accident and incident response. Radiological Detection System funding includes the procurement and fielding of 1,482 AN/PDR-77 Radiac Sets.
- Collective protection platforms include hard and soft wall shelters, vehicles, and structures. Collective protection funding includes the procurement and fielding of seven Chemical Biological Protective Shelter (CBPS) Systems and 36 Joint Expeditionary Collective Protection (JECP) systems. The CBPS provides the Forward Surgical Team (FST) and the Area Support Medical Company (ASMC) with a shelter that allows their mission to continue in a chemically/biologically degraded environment. The FST and ASMC, which by doctrine must function together, are critical assets to the Brigade Combat Team Commander. The CBPS also provides chemical protective shelter capabilities to the Role 1 Medical Treatment Facility (MTF)/Battalion Aide Station (BAS) mission.
- Decontamination funding includes the procurement and fielding of 35 High Mobility Decontamination Systems and 42 Mass Casualty Decontamination systems.

Sector Outlook

The CBRND sector provides critical capabilities to operationalize the warfighters' and first responders' abilities to maneuver in a broad spectrum of environments. It is imperative that the DoD proactively manage this critical asset in order to continue providing and improving capabilities to counter hostile nuclear, chemical, radiological, and biological weapons.

The CBRND Working Group continues to evaluate ways to efficiently provide CBRND products to the warfighter while promoting competition and innovation in the sector. Some of the potential options to consider and support are the expansion of current capabilities, use of alternate technologies to meet mission requirements, establishment of organic capabilities, application of existing legislative authorities to sustain capabilities or prioritize defense orders, and/or use of non-domestic suppliers. The authorities in DPA Title III, and potential expansion of these authorities, could provide opportunities to increase production capacity and attract new entrants.

GROUND SYSTEMS SECTOR

Sector Outlook

Ground systems provide defense-unique products for mobility and firepower, primarily to the Army and Marine Corps, and are divided into tracked and wheeled vehicles for combat, combat support, and combat service support. The ground vehicle sector of the DIB is comprised of a small set of prime suppliers which design and manufacture Combat Vehicles (CV) and Tactical Wheeled Vehicles (TWV), as well as the government-owned depots, arsenals, and test facilities that support the production and life-cycle sustainment of U.S. ground systems.[16]

Combat Vehicles

CVs are typically heavily armored and integrated with complex weapon systems, fire control, and sensors. This class of military ground vehicles tends to be defense-unique with little commercial application. The current CV industrial base suffers from a diminished number of capable domestic firms. When the U.S. Army first acquired the M1 Abrams Tank, there were seven firms or major technology suppliers within the CV industry. Through mergers and buyouts, the CV industry decreased to only two U.S. primes—one specializing in steel fighting vehicles and another specializing mostly in aluminum armored vehicles.

Although an assortment of other defense firms such as Lockheed Martin, SAIC and Textron occasionally compete for selected CV programs as a prime or major partner, BAE and GDLS largely dominate the combat vehicle subsector.

Tactical Wheeled Vehicles

While also designed to accommodate use in demanding military environments and missions, TWVs are usually trucks modified from commercial variants. As such, this class has a higher potential to benefit from dual-use or commercial developments. The industrial base supporting this subsector and the U.S. automotive market is highly integrated through complex supply chains, research and development operations, and shared assembly and production systems for component manufacturing.

Table 5: Ground Vehicle Production

Ground Vehicle Production								
				Production/Upgrade				Mods/ Sustainment
Manufacturer	Vehicle Type	Program	Activity	Projected Completion	Production Goal	Produced through 2019	Funding ($M) 2019-2024	Funding ($M) 2019-2024
BAE Systems	Combat	Bradley	Mods Upgrade	2019	271	271	205	2474
	Combat	AMPV	Production	2038	2,897	355	3778	
	Combat	ACV 1.1	Production	2021	204	56	961	84
	Combat	Paladin	Mods					
	Combat	Paladin (PIM)	Production	2031	689	237	3312	
	Combat	HERCULES	Production	2024	933	909	313	
General Dynamics	Combat	Stryker	Mods Upgrade		3,661	495	3015	1314
	Combat	M1 Abrams Tank	Mods Upgrade		2,101	1,580	8080	2846
	Tactical	GMV	Production		2,382	225	152	
Raytheon	Combat	LAV	Mods					393
SAIC	Combat	AAV	Sustainment					399
Leonardo DRS	Combat	JAB	Production		337	77	1340	
Oshkosh Defense	Tactical	JLTV	Production	2034	58,190	10,885	8480	
	Tactical	FMTV	Production		83,185	78,469	447	
	Tactical	FHTV	Production	2021	139,045	13,8872	279	
	Tactical	PLS-ESP	Production	2020	1,708	1,670	38	
	Tactical	HEMTT-ESP	Production	2020	9,249	9,092	203	
Oshkosh/ Navistar	Tactical	MRAP	Sustainment		8,222	8,222	0	
AM General	Tactical	HMMWV	Production		3,905	2,308	648	
Textron	Tactical	ASV	Production		2 per year	3	5	

Most the firms competing for TWV contracts also produce heavy trucks (i.e. waste removal, cement mixers, firetrucks, buses) or have complimentary businesses within the firm. As a result, there is the equivalent of "warm basing" in the TWV market, where firms can maintain the expertise and product line capability to ramp up production of TWVs with minimal U.S. government or DoD involvement. Although current production of TWVs is dominated by two domestic suppliers, there are multiple qualified vendors for the repair, refurbishment, and modifications business.

Sector Risks and Issues

In general, prime vendors within the DIB must account for the cyclical nature of shifting demand, declining budgets, and ever-changing requirements. The firms in the TWV market fare better than firms in the CV market due to commonality of products across both the Defense and Commercial product lines. However, following the draw-down of military forces following major combat operations in Afghanistan and Iraq as well as budget austerity, firms in both the TWV and CV industries have wrestled with declining demand, USG desire to own Technical Data Packages, cancelled programs, contract award protests, continuing resolutions, and changing requirements.

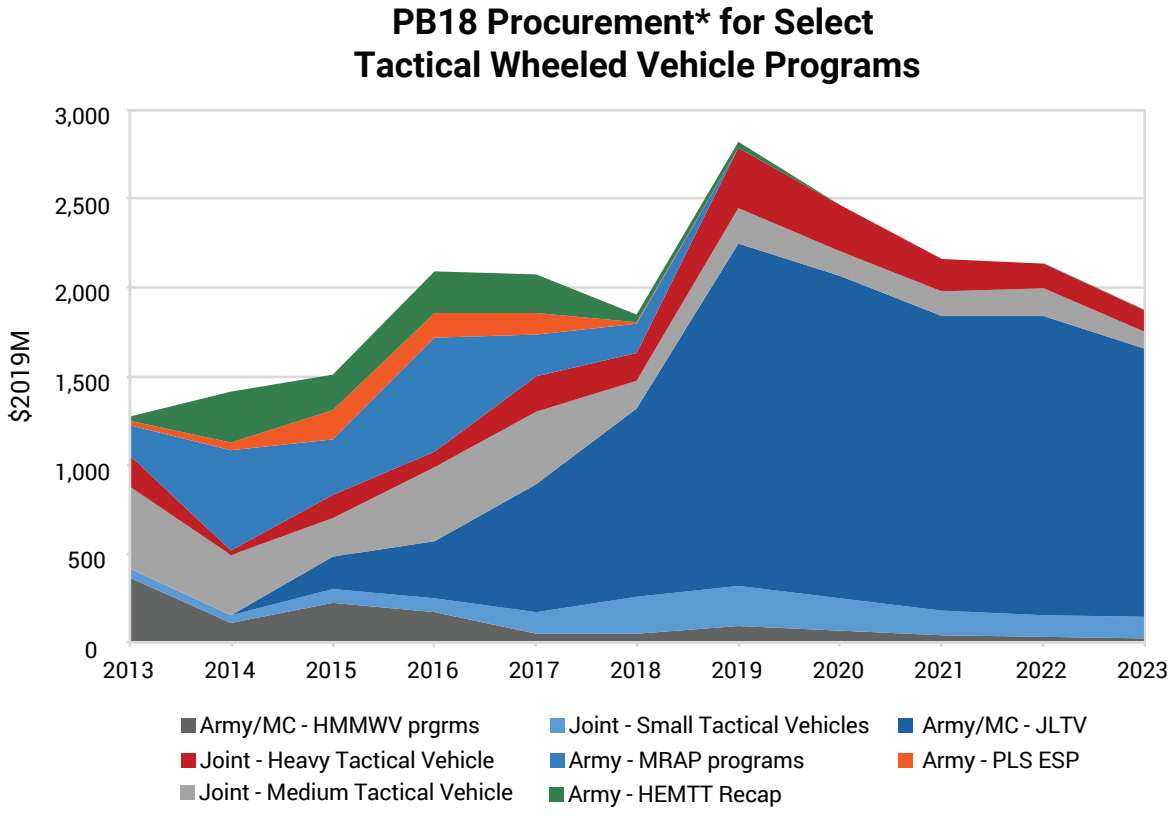


*Chart 18: * Years AFTER the Budget Year DO NOT include OCO funding; Years PRIOR TO and INCLUDING the Budget Year DO include OCO funding, if any*

Source: DoD Comptroller - 2014 thru 2019 Presidential Budgets

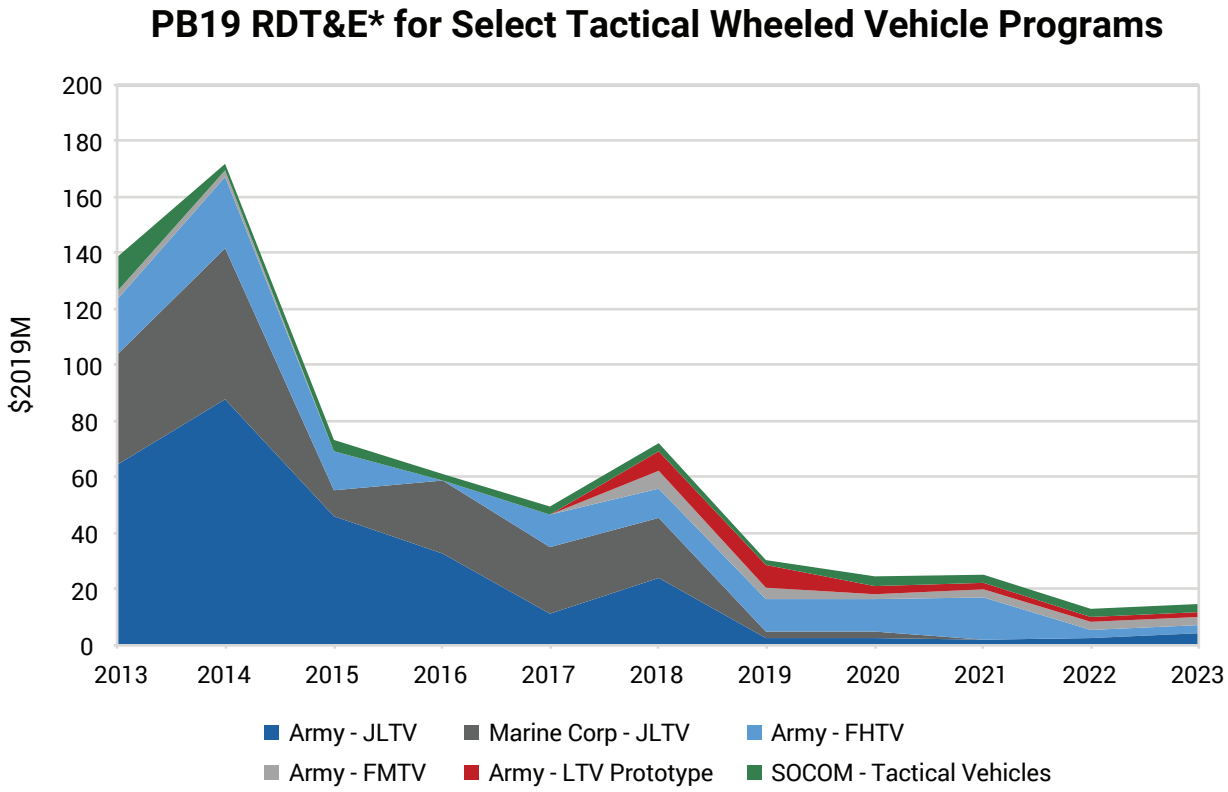


*Chart 19: * Years AFTER the Budget Year DO NOT include OCO funding; Years PRIOR TO and INCLUDING the Budget Year DO include OCO funding, if any*

Source: DoD Comptroller - 2014 thru 2019 Presidential Budgets

The U.S. ground vehicles sector lacks the capacity needed to support combatant commander requirements for upgraded capabilities through vehicle modernization and new vehicle programs. Over the last few decades, budget reductions and uncertainties have resulted in delays and cancellations in new ground vehicle programs. Instead, modernization efforts have favored recapitalization and incremental upgrades to legacy programs, rather than new-design programs.

Unstable demand drives private industry to reduce excess manufacturing capacity and investments in DoD production lines. This issue is particularly acute in CV production where one U.S. manufacturer is responsible for producing approximately 80% of all new armored vehicle production. Rapid increases in current demand for multiple new products continues to stress production capabilities at this manufacturing site, leading to program delays and quality control issues in multiple programs.

The ground vehicles sector lacks skilled labor necessary to meet present and projected needs. Overall, the welding workforce in the United States is in steady decline. As the vast majority of the current workforce approaches retirement, a new generation of skilled technicians is in short supply. Between 1980 and 2018, the total number of welders in the United States dropped by 23%, going from 550,000 to 424,700 total.[17] Despite abundant opportunities and competitive salaries offered by the manufacturing industry, public perception favors traditional career opportunities over trade and manufacturing specialties. According to a study completed by the Manufacturing Institute, the National Association of Manufacturers, and Deloitte, less than 30% of parents would consider encouraging their child to pursue a

manufacturing career.[18] Further, the pipeline of trade schools and reputable technical education programs that once educated the older generations of the workforce is fragmented. If the eroding technical skill base is left unaddressed, the ground vehicle sector will not be able to maintain the workforce needed to keep up with demand.

Inconsistent demand and aging infrastructure impair the ability to maintain current capacity and prepare for future needs in the organic industrial base. By law, the DoD is required to produce mortar tubes, large-caliber gun barrels, and howitzer barrels at one organic arsenal. Much like the private sector, fluctuating DoD demand makes it difficult to retain a tenable workload for the organic industrial base. This in turn leads to higher operational costs, aging infrastructure, inability to retain human capital, and inconsistent production management. To reduce the impact of oscillating demand, the DoD must modernize the organic industrial base to ensure its fitness to sustain current programs and meet future surge requirements

Notable Developments

As part of the future risk management actions in the ground vehicles sector, the DoD is increasing efforts to monitor the health, performance, and quality of the ground systems industrial base. Private industry as well as DoD components, including the military services, are making investments, contributing to recapitalization efforts, and considering acquisition and sustainment plans to reduce production backlogs.

Sector Outlook

Both the Army and Marine Corps have published long-term vehicle modernization strategies to align ground vehicle priorities with ground vehicle procurement profiles. Adhering to these strategies will help provide consistency to industry for planning and investment purposes.

- U.S. Army Combat Vehicle Modernization Strategy
- U.S. Marine Corps Ground Combat and Tactical Vehicle Strategy

Increased prototyping efforts can help increase opportunities to practice critical design skills and capabilities for CVs and TWVs. However, a challenge to the USG and DoD will remain the high cost of maintaining a warm manufacturing line for both CVs and components to enable surge production capability. Infrequent demand for CVs forces the DoD to pay a high premium for operations to reset, remanufacture, and sustain the fleet of CVs. Additionally, DoD must ensure reliable supply of key military unique CV components such as gun barrels, forward looking infrared (FLIR) cameras, engines, track, and tracked vehicle transmissions.

The TWV market remains relatively stable and healthy due to its foundation in the commercial truck manufacturing sector. However, as protection and lethality receive a growing emphasis in new developments, TWVs may develop to include more military-unique requirements. There is also room for improvement to ensure the TWV industry is better able to leverage and rapidly employ innovative products and processes, and critical skills between defense and commercial markets.

MISSILES AND MUNITIONS

Sector Overview

The missiles and munitions industrial base is comprised of "smart" bombs, tactical (cruise, air-to-air, air-to-ground, surface-to-air) missiles, missile defense, strategic missiles, and has expanded to include hypersonic weapons. It also includes "dumb" bombs, ammunition, mortars, artillery, tank rounds, etc.

The sector is primarily defense unique and largely subject to wartime needs—meaning that procurement ramps up during wartime and declines when conflict ends. The market is defined and hampered by this conflict-reliant pattern, creating significant management and viability challenges for suppliers and their sub-tier suppliers.

The missiles industrial base continues to suffer from the industry consolidation of the past several decades. Two (of five total) prime contractors account for roughly 97% of DoD's missile procurement funding. There are currently only two domestic suppliers for solid rocket motors used in the majority of DoD missile systems, with foreign suppliers making up the balance for a small number of systems. One of the foreign suppliers recently established a U.S. subsidiary for tactical solid rocket motors, which will increase the health of this key sub-tier supplier base.

Two (of five total) prime contractors account for roughly 97% of DOD's missile procurement funding

In the past, the U.S. chose not to weaponize its hypersonics capability. Meanwhile, potential adversaries dramatically increased their emphasis on weaponization of hypersonic technologies, creating potential capability gaps that the U.S. now must address. In response, the DoD has significantly increased investments in hypersonic systems to accelerate development and production. Hypersonic strike capability provides warfighters the ability to strike targets hundreds (and even thousands) of miles away in a matter of minutes, defeating time sensitive targets with highly survivable and lethal effects.

The DoD faces significant challenges in developing manufacturing capability for hypersonic weapons. Hypersonic weapons rely on state-of-the-art technology in several critical components, many of which are only available from non-traditional defense contractors. Technology development and industrial capacity scale-up must be balanced to field these weapons. Planned efforts in hypersonics will tap into new areas of the industrial base, but will also tax some of the existing base, particularly elements that support missile production within the sub-tier supplier base.

New demands for hypersonic weapons must be balanced with current demand for conventional missiles. Additional investment can make a big difference in the pace of development and the rate of capacity increases. Industry is willing to invest in production capacity and capability for hypersonics, but many suppliers are waiting on clear Government plans and forecasts to justify the business case for investment in their facilities and capabilities.

Private sector suppliers are of crucial importance to conventional munitions production—which does not include missiles. Historically, 70%–75% of procurement funding for munitions has been directed toward the private sector.

The ammunition and conventional munitions industrial base is critical to the life cycle management of more that 650 programs and 1,200 end items

The ammunition and conventional munitions base is critical to the life cycle management of more than 650 programs and 1,200 end items. As the Single Manager for Conventional Ammunition for all Services, the Army coordinates procurement from both organic and private sector suppliers, resulting in cost and contracting efficiencies.

Major Risks & Issues

The missiles and munitions industrial base is experiencing five major risks according to the categories identified in the 13806 Report. These include: 1) Obsolescence & Lack of Redundant Capability, 2) Visibility into Sub-tier Suppliers, 3) Loss of Design and Production; Aging Workforce, 4) Resilient Industrial Base: Surge and Gap Planning, and 5) Infrastructure: Manufacturing & Test Equipment, Test Ranges & Instrumentation. The identified risks and issues in the munitions sector cross all Macro Forces. Table I below cross references the major sector risks to the macro forces.

Table 6: Sector Risks vs Macro Forces

SECTOR RISKS		MACRO FORCES				
Item	**Description**	**Sequestration & Spending Uncertainty**	**Decline of US Manufacturing**	**US Govt Business Practices**	**Industrial Policies of Competitor Nations**	**Diminishing STEM & Trade Skills**
Obsolescence & Lack of Redundant Capability	Obsolescence, lack of redundant capability, foreign single suppliers are critical issues. Minimal Gov and Industry proactive and collaborative planning	X	X	X	X	
Visibility into Sub-tier Suppliers	Obsolescence issue is compounded by a lack of visibility into sub-tier suppliers, with heavy reliance on Prime contractors. Results in reactive action that causes delays in deliveries and additional cost.			X	X	
Loss of Design and Production; Aging Workforce	Many "new" systems are upgrades to existing systems, not new designs. Much of the workforce with design experience is at or near retirement age.	X	X	X	X	X
Resilient Industrial Base– Surge and Gap Planning	Resiliency in this manner connotes the ability of industry to withstand demand peaks and gaps. DoD does not plan nor budget for a resilient industrial base for missiles and munitions	X	X	X	X	X
Infrastructure– Manufacturing & Test Equipment, Test Ranges & Instrumentation	Facilities and core skills needed to operate are at a critical level due to declining research and development and maintenance budgets	X	X	X		X

Obsolescence & Lack of Redundant Capability

Ammonium Perchlorate (AP) Production: AP is a critical energetic oxidizer used in solid rocket fuel propellants with a decades-long history of use in rocket propellants, including space launch. There is currently only one supplier of AP in the United States, and the cost per pound has increased over 400% over the last fifteen years. Former suppliers have left the industry due to limited and inconsistent demand, which significantly reduced when the Space Shuttle program ended.

Specialty Chemicals from Foreign Sources: DoD relies on multiple non-domestic sources for many specialty chemicals, some from "non-friendly" sources. This presents a very real risk that supply could be interrupted in a conflict scenario, and/or non-allied nations could prohibit access for U.S. use, severely impacting our ability to produce munitions.

Large Solid Rocket Motor (LSRM) Production: The U.S. LSRM industry has tightly consolidated in the last 30 years. In 1990, there were five LSRM manufacturers in the United States. As of June 2018, only two manufacturers remain—Northrop Grumman Innovation Systems (NGIS - formerly Orbital ATK) and Aerojet Rocketdyne (AR).[19] That industrial capacity has the potential to narrow even further: in April 2017, AR announced it would shut down operations at its Sacramento, CA location by the end of 2019.[69] This was part of a corporate Cost Improvement Program, which consisted of consolidating multiple facilities, and reducing infrastructure and overhead to become more cost competitive.

Visibility into Sub-tier Suppliers:

DMSMS, including obsolescence and single point failures: Due to the relatively low quantity demand for many specialty materials, DoD relies on single source suppliers for many components and end items. In addition, obsolescence continues to be a major issue. Frequently, a component is too far down in the supply chain for DoD to have any visibility. Even when the issue is known, developing a replacement and extensive requalification efforts association with that replacement drive additional cost. Further, Federal Acquisition Regulations severely limit DoD's ability to interact directly with sub-tier suppliers in order to quantify supply risks and issues. Lastly, competitor nations are aggressively attempting to acquire critical sub-tier suppliers, either directly or through the higher-level ownership chain of the company, with limited visibility from DoD.

Loss of Design and Production; Aging Workforce

Hypersonics: Development and production of the many specialty materials and subsystems required for hypersonics is a niche area. The majority of the industrial base consists of small businesses that have focused their efforts on proving their technology and producing a handful of demonstration vehicles and glide bodies. Most of the workforce knowledge resides in these small companies. The traditional DoD industrial base is limited in production capability, resulting in large risks for cost, efficiency, and producibility. The industrial base is willing to self-invest in these capabilities, but a lack of definitive demand from DoD prevents them from justifying the business case.

Design and Manufacturing of Missiles and Munitions: The Missiles and Munitions industrial base is serviced by a growing percentage of personnel over the age 55, and an increasingly small percentage of midcareer employees between the ages of 35-44. Promising midcareer STEM and trade-skill oriented personnel are leaving the industry for other occupations. This is especially true for employees in the manufacturing components of the industrial base. Department of Labor recruiting efforts for STEM and trade skills recruiting has traditionally not focused on subject areas relevant to missiles and munitions. Continuing these practices could result in knowledge loss in critical areas of the industrial base, particularly in areas where re-engineering of obsolescent components is required, and where demand for new missile designs is increasing.

Resilient Industrial Base: Surge and Gap Planning

- **Accurately and Proactively Forecasting Demand for Munition Procurements:** Munition Procurement Demands have traditionally been calculated based on the Total Munition Requirement (TMR), which includes quantities for war reserves, training activity, and testing. However, when a munition is deemed to have met inventory requirements, procurement is usually suspended, allowing production lines to "go cold." This causes start-up problems and additional cost when DoD needs to produce that munition again.
- **Consistent Demand Signal for Missiles:** Due to the relatively large cost and low quantity of missiles procured, it is difficult to maintain consistent and steady production demand. Large shifts in demand cause perturbations in the production environment, impacting the supply chain as well as causing cost issues. Steady demand for missiles and missile components enables industry to better plan for longer term stable production, negating the risk of the production line "going cold" (impacting readiness), and enabling greater surge capacity. However, developing and executing missile production and delivery is the responsibility of the respective Service program offices. OSD has no authority to direct production rates or schedules. A few program offices are attempting to create a more stable and consistent annual production cycle, but there is no real incentive for a program office to implement this approach. In fact, there are many disincentives, such as obtaining lower unit pricing on larger, one-time batch buys; Program Manager goals and metrics to meet higher production rates; and unstable DoD inventories of end items (which drive spikes in production demand).

Infrastructure: Manufacturing & Test Equipment, Test Ranges & Instrumentation

- **Hypersonics:** Due to the decades-long lapse in hypersonic weapon development and production, facilities and infrastructure require major modernization. Unique production equipment must be replaced, modernized, and duplicated to sustain demand signals. Test ranges and instrumentation also require significant modernization. Significant investment is required in both industry and organic DoD facilities to achieve required capability and capacity.

Notable Developments

Energetic Materials

To address the Ammonium Perchlorate supply issue, INDPOL issued a Request for Information (RFI) in 2017 seeking information about domestic AP sourcing. Numerous companies responded, and there were several that expressed interest in establishing an additional U.S. source for AP. Along with the established supplier AMPAC, Northrop Grumman Corporation (NGC) has performed obsolete solid rocket motor washout and recovery of AP for over ten years. The recovered material has been used for commercial purposes including commercial launch vehicles, but not for DoD missiles and munitions. Growing out of that involvement, NGC is developing a capability to produce AP from domestic materials as a second source. Once online, yhis will support supply and price stability for this critical material for solid rocket motors.

To address the foreign source of supply risk, the CEMWG, established in 2013, executes a coordinated Department-wide approach to identify energetic materials and their ingredients that are at risk of becoming unavailable to the DoD in the short-term (within three years) and long-term (3- 10 years). The CEMWG quantifies the risk of non-availability and develops specific mitigation plans for materials determined to present an unacceptable level of risk to the Department. In 2019, CEMWG released a survey to government and industry to identify chemicals that are in this risk category. This is an

update to a 2016 survey that first outlined DoD chemicals that were at risk or had existing issues for availability. Since that time DoD has executed a number of mitigation activities. In January 2019, the President signed four Presidential Determinations (energetic chemicals, inert chemicals, precursor chemicals, and advanced manufacturing techniques for chemicals) to allow the use of Defense Production Act Title III funding to mitigate risk for critical chemicals for munitions. OSD Industrial Policy issued an RFI to identify options available to alleviate industrial base risk. INDPOL is also tracking development of advanced manufacturing technologies and scale-up efforts that could eliminate the need for foreign sources.

LSRMs

To address the LSRM risk, Aerojet Rocketdyne plans to reconstitute some manufacturing capability at their Camden, Arkansas facility, contingent on selection decisions within the Ground-Based Strategic Defense (GBSD) program. If not selected to support GBSD, AR has stated that it will exit the LSRM business, leaving the United States with only one supplier—NGIS.[71] Recently, Northrop Grumman has announced its intent to include AR as part of its national team for GBSD, so this risk may have been averted, but the GBSD program remains in source selection and any final decisions on LSRM providers for GBSD remain unknown.

Supply Chain Visibility

To address the lack of DoD visibility into the sub-tier supply chain, DoD instruction, DOD-I 4245.xx, DIMINISHING MANUFACTURING SOURCES AND MATERIAL SHORTAGES (DMSMS) MANAGEMENT, has been drafted and will soon be released for formal coordination and review, prior to publishing. Additionally, DoD Manual 4140.01 vol3 "DoD Supply Chain Materiel Management Procedures: Materiel Sourcing" was published in August 2018, providing government program offices best practices for managing their supply chain for materials. OSD also engaged with the Services on strategies for accessing supply chain data (capability and capacity) in an effort to proactively identify supply chain issues so they can be addressed as early as possible. Contracting language and guidance has been developed and released to aid Program Offices in addressing DMSMS in their contracts. Highlights include:

- Using DMSMS planning and management as a source selection criterion
- Mandating that contractors develop, maintain, and implement a DMSMS management plan (including attending government DMSMS management team meetings, flowing down requirements to sub-tier suppliers, performing supply chain monitoring, and applying predictive tools and methods to proactively forecast DMSMS issues)
- Requiring contractors to submit a Bill of Materials (BOM) at design and production reviews in support of sustainment activities
- Requiring contractors to provide technical data relevant to DMSMS issues
- Requiring contractors (at all tiers, not just the Primes) to notify the government directly within one week of discovering a DMSMS issue.
- Requiring contractors to propose and fund DMSMS mitigations (up to $1 million)

Hypersonics

In an attempt to quantify the risks in hypersonics development, production, and test capability, the Defense Contract Management Agency's Industrial Analysis Group conducted a study of the hypersonics industrial base and identified specific risk areas and mitigation strategies. Industrial Policy is assessing the risks and proposed strategies, in conjunction with OUSD (R&E), to produce a hypersonics industrial base roadmap which will prioritize mitigation options and inform funding requests. Significant increases in funding will be necessary to developing industrial base capabilities and capacities as program requirements are defined over time. Industrial Policy is also actively communicating with members of the National Technology Industrial Base to identify additional capability for the production and testing of hypersonics.

Production Capacity

The Department continues to conduct munitions readiness reviews, to ensure that munitions inventories are sufficient to meet requirements. Where shortfalls exist, DoD has conducted "munitions war rooms" designed to identify opportunities to provide munitions at a faster pace by either increasing production capacity or shortening lead times. Deep dives into each munition's industrial suppliers has been necessary to perform the analysis and implement solutions. However, these efforts are labor and data intensive, which limits the Department's ability to execute "war rooms" to only the highest risk items.

Sector Outlook

Increased activity in hypersonics will place increased demand on the munitions industrial base, and must be balanced with current non-hypersonic production requirements. Results from the recent hypersonics industrial base assessment will direct specific mitigation actions to strengthen the industrial base and inform future budget requests.

As a result of the actions from the 13806 report, the CEMWG, and the "war room" deep dive process, the Department has improved visibility into the health of the missiles and munitions industrial base and has already mitigated some high-risk areas. The Department will continue to assess and mitigate higher-risk areas to improve the health of the industrial base, particularly in the area of critical energetic materials. Deployment of the pending DoD Issuance for DMSMS Management and associated contract guidance will assist greatly in identifying and managing supply chain risk.

Industrial Policy will continue to advocate for the strategic assessment and implementation of modernization and expansion of Government Owned-Government Operated and Government Owned-Contractor Operated production facilities; as well as exploitation of previously underutilized facilities throughout the National Technology Industrial Base. Increased engagement with the US Manufacturing Institutes will support implementation of advanced manufacturing technologies, as needed, and strengthen and expand the capabilities of the US manufacturing workforce in key DoD technology areas.

NUCLEAR MATTER WARHEADS

Sector Overview

The Nuclear Matter Warheads Sector consists of government-owned, contractor-operated (GOCO) sites, and government furnished equipment used in the design, build, and test of our nation's nuclear warheads. The U.S. nuclear deterrent is a lynchpin in U.S. defense planning and that of U.S. allies and adversaries. Nuclear weapons are designed and produced to meet an "Always/Never" standard:

1. They must always work when authorized by proper authority, and
2. They must never work in any situation or environment (normal, abnormal, or adversarial) without authorization by proper authority.

Supply chain availability and integrity is crucial to achieving the "Always/Never" standard, but an increasing set of risks threaten the integrity of the enterprise. Some of the associated research, development, production equipment, and software are designed and produced in-house by the DoD's organic industrial base. However, the majority is procured from outside vendors.

Major Risks & Issues

Macro forces driving risk to the Nuclear Matter Warheads Sector are a reflection of the same forces driving risks to other sectors upon which the nuclear matter warheads sector is dependent (e.g., machine tools, electronics, materials, etc.). Chief among those macro forces is the globalization of supply chains for software, materials, and equipment.

Clearable Workforce

U.S. faces a diminishing supply of clearable labor with the advanced education and training necessary for designing, producing, and stewarding nuclear weapons. The primary source of that labor, U.S. colleges and universities, generate insufficient U.S. citizen graduates in STEM areas relevant to the nuclear enterprise. The U.S. also lacks labor with important trade skills, including welders. Additional challenges due to clearance requirements greatly reduce the available pool of labor.

Microelectronics/Electronic Components

Nuclear warheads depend on trusted sources of microelectronics and electronics. However, due to diminishing U.S.-based microelectronic and electronic manufacturing capability, it is challenging to ensure that finished assemblies, systems, and subsystems exclusively leverage trusted, discrete components due to diminishing U.S.-based microelectronic and electronic manufacturing capability.

Critical Materials

Various sole source materials, addressed through the Nuclear Posture Review, are unavailable through trusted sources in sufficient quantities to ensure a robust and independent nuclear capability throughout a weapon's lifecycle. The problem is exacerbated by policies and requirements that either limit or place restrictions on procurement options, e.g., life of program buys.

Software Systems/Applications

Lack of trusted sources of software design tools, data management systems, manufacturing execution, and facility controls introduce risk to the nuclear weapons engineering environment. This problem is exacerbated by poor cybersecurity practices of many key software vendors.

Analytical and Test Equipment

Given current nuclear weapons test restrictions, specialized analytical and test equipment is essential to ensure the "Always/Never" standard of nuclear weapon performance. Components, subsystems, and systems must be tested to unique qualification standards, but the supplier base for certain test equipment is increasingly globalized and not trusted, leading to uncertainty in testing.

Notable Developments

The B61-12 Life Extension Program (LEP) will integrate DOE efforts to extend the service life of the warhead with DoD efforts to develop a guided Tail Kit Assembly (TKA) required to maintain current B61 mission characteristics. Programmatic integration of the Air Force-led, joint DoD-DOE program is accomplished through the B61 LEP Project Officers Group (POG) and its subgroups. The USAF is responsible for development, acquisition, and delivery of a guided TKA and for All Up Round (AUR) technical integration, system qualification and fielding of the B61-12 variant on multiple platforms. The production effort for the B61 TKA includes the production and delivery of TKAs, accessories, spares, ancillary equipment, trainers, lot acceptance test assets, and support. The program received the signed MS C ADM authorizing the B61 Mod 12 LEP TKA program to enter into the Production and Deployment phase on October 26, 2018.

The National Nuclear Security Administration, in coordination with the DoD, is also extending the life of the W80-1 warhead as part of the W80-4 Life Extension Program (LEP). The W80-4 will be used on the Long-Range Standoff weapon which is expected to replace the legacy Air Launched Cruise Missile (ALCM) in the mid 2020 timeframe.

Sector Outlook

The Nuclear Matter Warheads Sector is increasingly challenged by reliance on foreign vendors for the supply and maintenance of advanced machine tools, and dependent on globalized complex supply chains for materials and components. Recent and ongoing life extension programs opportunities to address some of these vulnerabilities as new contracts and supply chains and developed.

RADAR AND ELECTRONIC WARFARE

Sector Overview

Military radars and electronic warfare (EW) systems play a significant role in meeting our national security objectives.

Radar is essential to detecting the presence, direction, distance, and speed of targets such as aircraft, ships, and weapons; and for controlling flight and weaponry. Although there is some overlap with the commercial sector, military radar system requirements are often more stringent than those imposed on commercial systems as they are required to operate in the harshest environments in order to support combat operations.

EW) refers to military action involving the use of electromagnetic energy and directed energy to control the electromagnetic spectrum or to attack the enemy. EW systems continue to become a more integral element of military weapon systems as the U.S. seeks to ensure friendly, unimpeded access to the electromagnetic spectrum while denying our opponents the same advantage. EW includes capabilities for electronic attack, electronic support, and electronic protection, which are dependent upon technologies like those found in radar systems, including receivers and transmitters.

The DoD has roughly 100 radar systems in development, production, or sustainment with a similar portfolio of electronic warfare systems. These systems provide critical mission capabilities in four operational domains; land, air, space, and sea. A total of 23 firms produce, or have produced radars, for the DoD, however, three domestic suppliers (Raytheon, Northrop Grumman, and Lockheed Martin) dominate the domestic radar market, and four domestic suppliers (L3 Harris, BAE Systems, Raytheon, and Northrop Grumman) dominate electronic warfare systems.

Major Risks & Issues

Five major risks drive the Department's risk mitigation efforts:

Availability of electronic components

This risk is driven by aging DoD systems that lead to obsolescence of available components, the fluidity of commercial technology, and decreasing U.S. industrial and manufacturing infrastructure.

Availability of vacuum electronic device materials, components, and manufacturing sources

This risk is driven by requirements to leverage multiple sole and single source material suppliers both internal and external to the U.S.; market fragility with the growth of the Gallium Nitride Solid State based systems; and decreasing industrial and manufacturing infrastructure.

Lack of availability of software developers and STEM employees

This risk is driven both by the ratio of U.S. to non-U.S. STEM and software engineering students in college, and the commercial demand for software developers as more commerce is being conducted over the internet and personal electronic platforms are growing.

Reduced competition and innovation for tactical radar and EW systems

The F/A-18 Active Electronically Scanned Array (AESA) is a prime example as similar AESA radars are being produced for other applications. Once F/A-18 production ends, only a single qualified source will remain.

Sole domestic source for chaff countermeasures and capacity issue for flares

This risk is highlighted by the lack of commercial application for chaff and flares which leads to low volume requirements, as well as manufacturing challenges with materials that lead to deflagrations at the manufacturers, impacting production capability.

Notable Developments

The Department of Defense supports multiple programs designed to mitigate identified risks in the radar and electronic warfare sector.

Gallium Nitride (GaN)

The Office of Secretary of Defense Manufacturing Technology (ManTech) program and the Microelectronics Innovation for National Security and Economic Competitiveness (MINSEC) program both support efforts related to GaN manufacturing. GaN technologies are a significant enabler for AESA-based radar and EW systems, and are in competition for GaN production with commercial demand.

Two active DPA Title III efforts are aimed at improving GaN production capabilities for current manufacturers to ensure the industrial capacity can meet current DoD requirements. In addition, the IBAS group is funding projects to move toward open systems architecture for electronic warfare systems. This will expand competition to lower tier suppliers by removing barriers emplaced by proprietary software. IBAS projects also look to open the GaN and unmanned aircraft system (UAS) manufacturing supply base to sub-tier suppliers. The Department has moved quickly to award contracts to mitigate supply chain risks in other areas such as digital receivers/exciters, and to investigate risks in emerging areas such as directed energy weapons.

Modern Advanced Digital Receiver Exciter

In FY2019, the IBAS program awarded a contract to a lower tier, non-traditional defense company to design and build a modern advanced digital receiver exciter (DREX). Plans are in place to join the DREX with solid-state technology as part of a technology insertion into legacy radars, or as part of a new AESA design to improve existing capabilities, address obsolescence, and improve reliability and performance of existing radar systems. In addition to

the above task, the company is directed to support the development of software programming capabilities for the DREX and to address training for future and existing software engineering requirements.

Projects were funded in FY2019 to invest in enabling sub-tier manufacturers to mature their manufacturing processes that will promote competition for repair and support of fielded AESA radar systems. Additional projects are underway that focus on developing new manufacturing techniques to enable lower cost and more efficient packaging technologies. These projects are targeting improvement in thermal management within the radar and EW systems that can enable smaller and lighter systems and potentially higher power systems within the same size, weight, and power requirements.

Vacuum Electron Tubes

Multiple efforts were undertaken in FY2019 to mitigate risk areas impacting the vacuum electron tube industry.

On July 22, 2019 President Trump authorized the use of the DPA to initiate projects which can reduce reliance on foreign sources for rare earth elements. Rare earth magnets and materials are required not only to support the vacuum electronics industrial base and the radar and EW community, but are also required to support precision guided munitions, laser systems, sensors, and actuators on airborne platforms and future electronic propulsion systems. Presidential Determination letters were signed to enable risk mitigation in five focus areas:

1. Light Rare Earth Element Separation and Processing
2. Heavy Rare Earth Element Separation and Processing
3. Rare Earth Metals and Alloys
4. Samarium Cobalt Magnets
5. Neodynium Iron Boron Magnets

A DoD wide technical working group led by the OSD Title III office is developing the required technical data packages to allow solicitation of these projects.

Additional projects in FY2019 aimed to develop new sources and materials to mitigate the use of foreign sourced thoriated tungsten and tungsten rhenium wire required for use in the vacuum electronics industry. The DLA and the OSD Title III program are supporting those respective efforts, which are scheduled to continue into FY2020.

Radar Working Group

In FY2019 the IBAS program formed a multi-service radar working group that will research core issues, develop action plans, and identify key leveraging opportunities.

Sector Outlook

The IBAS program is undertaking the task of developing a radar supplier industrial base resiliency plan. The multi-service radar working group will use the data collected through its research efforts to develop the Radar Supplier Resiliency Plan, which is expected to be submitted to Congress in the third quarter of FY2020.

IBAS has also initiated a working group to identify gaps in the Directed Energy Industrial base. The working group is looking at gaps within the U.S. industrial base as well as issues related to a lack of capacity to transition systems out of development and into production-level manufacturing capabilities. Directed energy capability is an emerging area of investment and interest. Both laser and high-power microwave systems are in the research and development phase, and these technologies and industrial base areas often align with radar and electronic warfare industrial base risks.

Lastly, regarding the risk area of chaff and flare countermeasures, the Office of Secretary of Defense commissioned a study to more explicitly define the risks in these areas and generate a set of recommendations. That study has been completed and efforts are ongoing to determine the appropriate plan of action and funding requirements needed to resolve the identified risks.

SHIPBUILDING

Sector Overview

The shipbuilding industrial base is responsible for every aspect of shipbuilding from design to decommissioning of aircraft carriers, submarines, surface ships, and their weapons and command and control (C2) systems. Over the previous five decades, the industrial base has experienced significant consolidation. Fourteen defense-related new construction shipyards have closed, three have left the defense industry, and one new shipyard has opened.

Shipyards are fixed facilities with dry docks and fabrication equipment that support construction, repair, conversion, alteration, repair, modernization and deactivation of new and legacy ships, and their weapons and C2 systems. The sector also includes manufacturing and other facilities beyond the shipyards, which provide parts and services for shipbuilding activities. Today, the Navy contracts primarily[20] with seven private new-construction shipyards, owned by four prime contractors, to build our future Battle Force, representing significantly less capacity than our principal competitors.

There are also a number of smaller private-sector shipyards and facilities building non-battle force and unmanned vessels, in addition to four public naval shipyard which perform repairs and maintenance. If faced with the demands of a major conflict it may be possible to engage other industries and shipyards. However, the cost and extent of such assistance is currently unquantifiable.

Furthermore, not every prime contractor and shipyard can build every ship type. The shipbuilding industrial base can therefore be further segmented by ship type: aircraft carriers, submarines, surface combatants, amphibious warfare, combat logistics force, and command and support vessels—each with their own unique risks and vulnerabilities.

Table 7: Private Sector Shipyards

PRIVATE SHIPYARDS			
SHIPBUILDER	**SHIPYARD**	**CAPABILITIES**	**PROGRAMS**
General Dynamics	Bath Iron Works (BIW)	Surface Combatant	Arleigh Burke Class Destroyer (DDG 51) Zumwalt Class Destroyer (DDG 1000)
	Electric Boat (EB)	Submarine	Columbia Class (SSBN) Virginia Class (SSN)
	NASSCO	Command/Support	Expeditionary Transfer Dock (ESD) Expeditionary Mobile Base (EMB) Expeditionary Sea Base (ESB)
		Combat Logistics	TAO Fleet Oiler
Huntington Ingalls	Newport News	Aircraft Carrier	Gerald R. Ford Class (CVN)
		Submarine	Surface Combatant Virginia Class (SSN)
	Ingalls	Surface Combatant	Arleigh Burke Class Destroyer (DDG 51)
		Amphibious Warfare	San Antonio Class Amphibious Transport Dock (LPD 17) America Class Amphibious Assault (LHA 6)
Lockheed Martin	Marinette Marine (MM)	Surface Combatant	Littoral Combat Ship (LCS)
Austal	Austal	Surface Combatant	Littoral Combat Ship (LCS)
		Fleet Support	Expeditionary Fast Transport (EFP)
Gulf Island Fabrication	Gulf Island Shipyards	Fleet Support	Navajo Class Towing, Salvage, and Rescue Ship (T-ATS 6)

Table 8: Public Sector Shipyards

U.S. Naval Shipyards (NSY)	
SHIPYARD	**CAPABILITIES**
Portsmouth Naval Shipyard (PNS)	Only East Coast NSY capable of refueling Los Angeles Class submarines. Capable of working on Los Angeles and Virginia Classes
Norfolk Naval Shipyard (NNS)	Only East Coast NSY capable of docking aircraft carriers. Capable of working on all classes of Navy Vessels
Puget Sound Naval Shipyard and Intermediate Maintenance Facility (PSNS & IMF)	Primary West Coast NSY for support of aircraft carriers. Only nuclear reactor disposal/recycling site
Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility (PHNSY & IMF)	Largest repair facility between the West Coast and Far East. Capable of working on surface combatants and submarines

Source: Public Shipyard Overview (Source: PB20 OP-5A)

Major Risks & Issues

In FY2019, five risks were paramount to the shipbuilding industrial base: a dependence on single and sole source suppliers, capacity shortfalls, a lack of competition, a lack of workforce skills, and unstable demand. The diminishing domestic commercial shipbuilding sector increases these risks.

Capacity Shortfalls

The increase in ship construction to reach a Navy fleet of 355 ships will strain the current U.S. shipbuilding sector. The COLUMBIA Class submarine program is expected to start production in 2021. In addition, the Navy has added 11 more surface ships to their procurement plans across the FYDP and the production output for VIRGINIA Class increased to two ships per year in 2016. This expected increase in submarine demand and the steady growth in the Navy's long-range plan for construction of naval vessels represents great news for the U.S. shipbuilding industry. However, the additional workload is a significant increase from current production levels and will place strain on shipyards as they expand and adjust to meet larger production volumes.

Sole Source Suppliers

The number of domestic suppliers at the lower tiers has declined in the last 20 years. The limited availability of suppliers requires the Navy to consider the workload and financial health of the supply chain when making procurement decisions. In the lower tiers of the supply chain, the size of the market results in the selection of single or sole sources of supply for critical products to promote resiliency during low production periods.

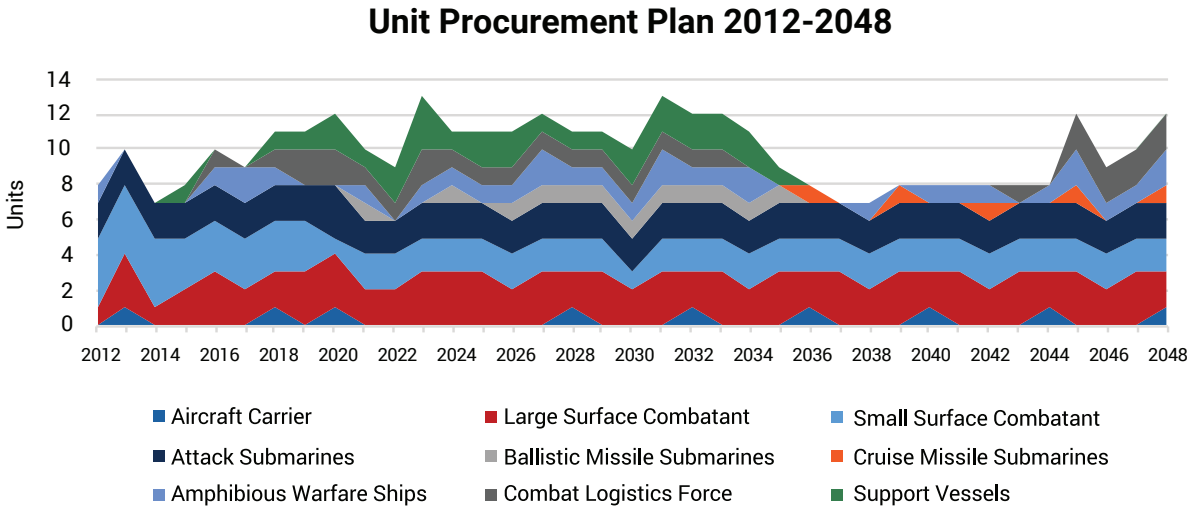


Chart 20: Source: Department of the Navy's (DoN) 30-year shipbuilding plan for FY2020-FY2049

Lack of Competition

There are currently four prime contractors producing nearly all of the Navy's ships, and two that comprise the vast majority of shipbuilding sales. A limited number of yards, and the size and complexity of operations, makes it prohibitively difficult for new businesses to enter the market. Only one shipbuilder is currently producing aircraft carriers, and only two are producing submarines, after a decision by the Navy to divide new work between Electric Boat and Newport News.

Table 9: Shipbuilding Prime Contractors

Company	Yard(s)	Latest 12 Months	Corporate Sales (Millions USD)	Corporate Operating Margin %	Corporate % Long-Term Debt to Total Capital	US Shipbuilding Sales (Millions USD)
Austal LTD (Austal USA Parent)	Austal USA	30-Jun-19	1,324.1	4.6%	15.2%	1,052.9
Fincantieri SPA (MMC Parent)	Marinette Marine Corp	31-Dec-18	6,456.2	4.1%	24.5%	80.2
General Dynamics	Bath Iron Works, Electric Boat, NASSCO	31-Dec-19	39,350.0	11.8%	35.9%	9,183.0
Huntington Ingalls Industries	Ingalls, Newport News	31-Dec-18	8,176.0	11.6%	45.8%	7,329.0

Unstable Demand

Fluctuations in modernization and procurement funding is also a long-term challenge, as changes in ship procurement plans impact the shipyards and lower-tier suppliers' workload. The timing of ship procurements is also critical to achieve the stable workload required to support the viability of the shipbuilding industrial base and to sustaining a skilled workforce. Advanced procurement for long lead time material and economic order quantities, as well as multi-program material purchases, continue to be used to ensure stability in the industrial base.

Workforce

Across the U.S., many industries are challenged to fill positions with qualified people. Blue collar employment in fleet concentration areas is a particular challenge. To help address this, the Navy will look for opportunities at the state and federal levels to obtain funding for training programs in order to grow the pool of available workforce. Private shipyards' ability to provide workforce stability is tied to Navy's ability to predict workload as described above. The Private Sector Improvement (PSI) initiatives will provide opportunities for industry to improve efficiency and invest in their workforce. For public shipyards, the Navy achieved 36,100 full time employees in FY2019, one year sooner than originally planned. To bring new hires up to speed more quickly, the public shipyards have developed an improved training model that gets new hires to the waterfront where they can learn hands-on, under the tutelage of experienced journeyman, shortening the time to productive contribution for new employees from up to two years to now under six months.

Notable Developments

The shipbuilding sector remained stable during FY2019 with five ships delivered: one Arleigh Burke Class destroyer (DDG 117), three littoral combat ships (LCS 15, 17, and 20) and one Spearhead Class expeditionary fast transport (T-EPF 10).

In FY2019, 15 ships were awarded by the U.S. Navy: two Gerald R. Ford Class aircraft carriers, one Arleigh Burke Class guided missile destroyer, one San Antonio Class amphibious transport dock, three littoral combat ships, two Lewis B. Puller Class expeditionary sea bases, two Spearhead Class expeditionary fast transports, two John Lewis Class fleet replenishment oilers and two Navajo Class towing, salvage, and rescue ships.

Priorities

The SSBN 826 (COLUMBIA) Class Ballistic Missile Submarine Program remains the top priority for the Navy and delivering that program on time without impacting other shipbuilding programs is a challenge. Advanced procurement funding is critical to the success of the program and necessary for the submarine industrial base to prepare for the largest workload increase in recent times.

Sector Outlook

Two governing documents guide the Navy's way forward for shipbuilding. First, the Naval Shipyard Development Plan Report to Congress (March 2018) provides a detailed workforce development plan. Second, the Shipyard Infrastructure Optimization Plan (SIOP) provides the strategy to optimally size, configure, and locate facilities at the four public shipyards to best execute mission requirements. The SIOP includes engineering analysis and strategy for optimal placement of facilities and major equipment at each public shipyard, which will restore badly outdated facilities while simultaneously reducing total personnel and material travel and movement by an average of 65%, effectively recovering 328K man-days per year. The SIOP includes a 20-year investment plan for infrastructure needed to support the shipyard capacity and capability the Nation needs.

For private shipyards, the Navy, in conjunction with the ship repair industry, is developing Private Shipyard Optimization (PSO) initiatives for optimal placement of facilities and major equipment in each region. This includes an investment plan for infrastructure needed to support a 355-ship Navy. The Navy is also implementing a (PSI) program that addresses workload stability, governance, contracting, and process optimization. The goal of the PSO and PSI initiatives is to identify and eliminate barriers to private sector ship availability throughput to affordably achieve on time delivery of surface ships.

The Navy's long-range plan for construction of naval vessels will help stabilize the industrial base and mitigate industrial base risks. This plan provides scalable acquisition profiles that promote stable workloads and efficient operations while encouraging industry investment in capital improvements, capital expansion, and a properly sized world-class workforce. Contracting tools such as multiyear procurement contracts, block buy contracts, economic order quantity (EOQ) buys, capital

expenditure (CAPEX) incentives, and shipbuilding capability preservation agreements can help support industry partners while focusing on affordability and cost control. The Navy will continue to utilize acquisition strategies and procurement profiles that allow them to sustain competition and increase efficiency while supporting the shipbuilding industrial sector.

Priority areas for the shipbuilding sector in coming years include industrial base capacity and capability, shipyard level loading, and workforce and facilities investments.

Industrial Base Capability and Capacity

Sustaining 355 battle force ships will require modernization and expansion of public and private industrial capability and capacity. The Navy regularly engages with industry via the Shipbuilders Council of America and regional ship repair associations and provides quarterly port loading assessments to Industry and to Congress.

The Navy conducted a market survey of private shipyards for available and potential commercial dry docks and is developing a long-range plan to increase the number of available certified dry docks. The PSI initiatives address industrial base health and workload stability, contracting, change management, and availability execution at private shipyards. For example, PSI initiatives include a change in how growth and new work items are approved. Small value changes historically account for 70 percent of growth and new work, utilizing pre-priced changes will significantly reduce cycle time for approval. Full implementation of the SIOP and PSO/PSI initiatives are key to meeting shipbuilding requirements, and will focus on future requirements for dry docks, facilities, and capital equipment modernization.

Shipyard Level Loading

The Navy is committed to working with private industry to provide them a stable and predictable workload in a competitive environment, so they can hire the workforce and make the investments necessary to maintain and modernize the Navy's growing fleet. This will help ensure the Navy attains the best value for the taxpayer. The Navy continuously works to smooth the workload by addressing identified peaks and valleys in the workload. Like the private shipyards, the public shipyards benefit from a stable and predictable workload enabling them to conduct the work, train the workforce, and maintain their infrastructure.

Workforce

The shipbuilders, in conjunction with the Navy, are working to develop and retain a skilled workforce that is able to support the future workload. Shipbuilders are investing in recruitment activities, training, apprentice programs, and other initiatives that will help to meet the increased demand for critical trades. The Navy continues to engage with its shipbuilders and suppliers, as well as regional and national associations, to address workforce challenges across the industry, such as training, mobility, and demand stability.

Facilities Investment

The SIOP initiatives provide a roadmap of future investments to improve facility infrastructure to support maintenance and modernization work in private and public shipyards. Investments in government facilities to support private sector work (piers and access) are also required and the PSO will provide a similar roadmap.

DoD will continue to work closely with shipbuilding contractors to ensure that equipment, system, and component suppliers are able to support the increased demand associated with building a larger fleet.

SOLDIER SYSTEMS

Sector Overview

Soldier systems are the diverse products necessary to maximize the warfighter's survivability, lethality, sustainability, mobility, combat effectiveness, and field quality of life by considering the warfighter as a system. This sector includes the weapons, body armor, clothing, footwear, radios, sensors, power supply, shelters, food, and other Service-member support items essential to executing many distinct U.S. military missions—from snipers to tankers to airmen to divers.

Most soldier systems have significant commercial overlap. The commercial market provides stabilizing revenue for existing defense contractors, as well as opportunities for new players to modify commercial gear and enter the defense market. Companies in the sector navigate technical advancement at funding levels typically well below major defense programs, stringent quality control and affordability challenges in high volume production, legislation and regulation promoting domestic sourcing and restricting technology proliferation, unique defense requirements that can rapidly evolve with a wartime threat, and defense demand volatility that varies proportionally with operational tempo. The advanced designs and novel industrial capabilities needed to preserve U.S. warfighter tactical advantage require a skilled workforce and modernized industry to compete internationally.

Major Risks & Issues

Industrial capability gaps in the soldier systems sector reduce U.S. assurance that the warfighter is adequately prepared to successfully execute defense missions in any operating environment. Often, supply disruptions can directly impact planned deployments. Evident industrial base risks in the soldier systems sector include single sources, capacity constraints, foreign dependency, market fragility, and diminishing manufacturing sources and material suppliers. The case studies below illustrate examples where the risk of permanent capability loss is enough to potentially warrant government action.

Erosion of the U.S. Textile Industry

Between 1995 and 2009, the U.S. textile industry suffered a historic contraction and Asian markets now dominate global textile supply. U.S. manufacturers are at a competitive disadvantage in workforce and raw material costs and availability. DoD is reliant on single and foreign sources, and competes with commercial demand for adequate production capacity.

Erosion of U.S. Rechargeable and Non-Rechargeable Battery Industry

Characterized by irregular demand, the military battery industrial base is diminishing. Military-unique requirements can differ from commercial demands in size, quality, safety, power density, weight, and environmental ruggedness. Lack of stable production orders, inadequate research & development investment, and disjointed acquisition strategies have resulted in lost capability and capacity, increased surge lead times, workforce erosion, and inhibited investments by remaining suppliers. Surge-capacity-limiting constraints occur at several points along the value chain, from raw material to final battery assembly. Most battery configurations are produced by single sources of supply. The rechargeable battery market is dominated by commercial demand and primarily foreign sourced. Domestic rechargeable battery producers cannot compete in production volume or labor availability and cost.[21]

Most domestic lithium ion cell packagers rely on foreign commercial lithium ion cell suppliers from countries such as South Korea, China, and Taiwan. The rapid expansion of the electronic vehicle market is likely to exacerbate these risks, especially if the designs deviate significantly from military requirements, foreign markets drive adoption, and foreign competitors lead the way in forward-looking manufacturing infrastructure investment.

Erosion of U.S. Photonics and Optics Industries

Photonics and optics are the principle underpinning technology drivers for warfighter sensing and laser systems. Sensing technologies and applications have exponentially expanded over the last few decades. They are increasingly integrated into every facet of warfighting to bring superior lethality and battlefield advantage. Although many key innovations emanate from the U.S., value added manufacturing has eroded over the last 20 years, threatening U.S. first access and assured access to new optics and photonics defense capabilities.

U.S. value added manufacturing has eroded over the last 20 years, threatening U.S. first access and assured access to new optics and photonics defense capabilities

Competitor nations in Europe and Asia have made key manufacturing infrastructure investments and have access to human capital, especially at lower cost, which provide a competitive advantage. Human capital gaps in skilled blue-collar workers and clearable U.S. nationals with advanced degrees in optics and photonics constrain the domestic defense industry. Additionally, rapid technology proliferation brings a risk of parity with competitor nations in the market. The result is U.S. reliance on foreign sources for key technologies and industrial capability for defense systems like night vision. Future advancements in flexible displays, OLEDs, and quantum mechanics offer opportunities to regain international competitive leadership in both technical innovation and manufacturing.

Government Business Practices

Commercial items, specifically modified within regulatory parameters to meet military specifications (MILSPEC), can require unique-enough industrial capabilities that oppose market dynamics and fuel industrial base risk. MILSPEC qualification processes can be significant barriers to entry and in some cases, are a constant source of production

technical risk. Where significant difference exists between market-stable commercial solutions and defense products, the government will be left to continuously fund the capability and capacity needed to produce military-specific items. While this is necessary in some cases, it is costly and impractical across the broad soldier systems portfolio. Likewise, in a few cases of high-volume soldier systems (e.g. body armor, uniforms, batteries, etc.), a small industrial base is further divided by contract awards to produce military department (MILDEP)-specific variants of comparable products. Disjointed acquisition strategies can unknowingly create single sources, decrease demand signal strength and visibility, increase logistics burden, and create industrial base risk. As part of the planned risk management actions in the sector, DoD will evaluate joint requirements and acquisition strategies for prioritized warfighter systems shared across the military departments with an objective to create a more attractive, manageable demand signal to industry and, where appropriate, adjust requirements to better align with market-stable solutions.

Notable Developments

Mergers and Acquisitions

- The July 2019 L3-Harris merger would have contracted the available sources from two primary domestic sources of night vision image intensifier tubes down to one, however, as a requirement of the antitrust review process, Harris divested its night vision business, which was acquired by Elbit Systems of America, LLC (ESA).[22,23] Though this avoided potential anticompetitive impacts and sustained a second source, it deepened foreign reliance for important night vision industrial capability.
- In July 2019, Avon Rubber P.L.C. announced a proposed agreement to acquire 3M's ballistic-protection business and the rights to the Ceradyne brand.[24] Avon is a U.K.-owned DoD supplier of chemical, biological, radiological and nuclear personal protective equipment. Consistent with policy, DoD is monitoring the transaction and reviewing for foreign influence, loss of competition, single source dependencies, capacity constraints, and other industrial base risks.

Industry Assessments

- Senator Inhofe, as Chairman of the Committee on Armed Services, requested the Under Secretary of Defense (Comptroller) provide an analysis of the night vision commercial and defense industrial base to be performed by the Under Secretary of Defense (Acquisition & Sustainment). The DoD relies on foreign sources for key technology and industrial capabilities. The transition from analog to digital night vision systems is a transition from dependence on component production of specialty image intensifier tube hardware to reliance on commercial electronics enhanced by unique software. While there is some robustness gained in that transition, there is also a shift to reliance on Asian Pacific Rim nations and a commercial-driven global market where the DoD has limited influence and must compete for access.
- Senate minority leader Schumer and Senator Ernst sent an inquiry to the Deputy Secretary of Defense on the state of the domestic organic light emitting diode (OLED) display industrial base and related DoD risk management strategies. At least two domestic OLED supply alternatives are available as well as alternative display technologies. The DoD has made investments to manage the risk, is actively engaged with suppliers, and is monitoring the niche industry closely.

Sector Outlook

Strategic Competition. Russia has been modernizing its soldier systems ensemble in a coordinated, modular, and evolutionary program called "Ratnik" - or "Warrior" - reported over the last five years. The program integrates and upgrades all aspects of soldier systems. Ratnik was deployed at least as

early as 2015[25] and improvements continue to roll out. The latest generation integrates exoskeletons, advanced sensing, and unmanned systems,[26] which parallels USSOCOM's Tactical Assault Light Operator Suit (TALOS).[27] Since 2010, Russia has significantly modernized its ground forces and ground troop tactics.[28]

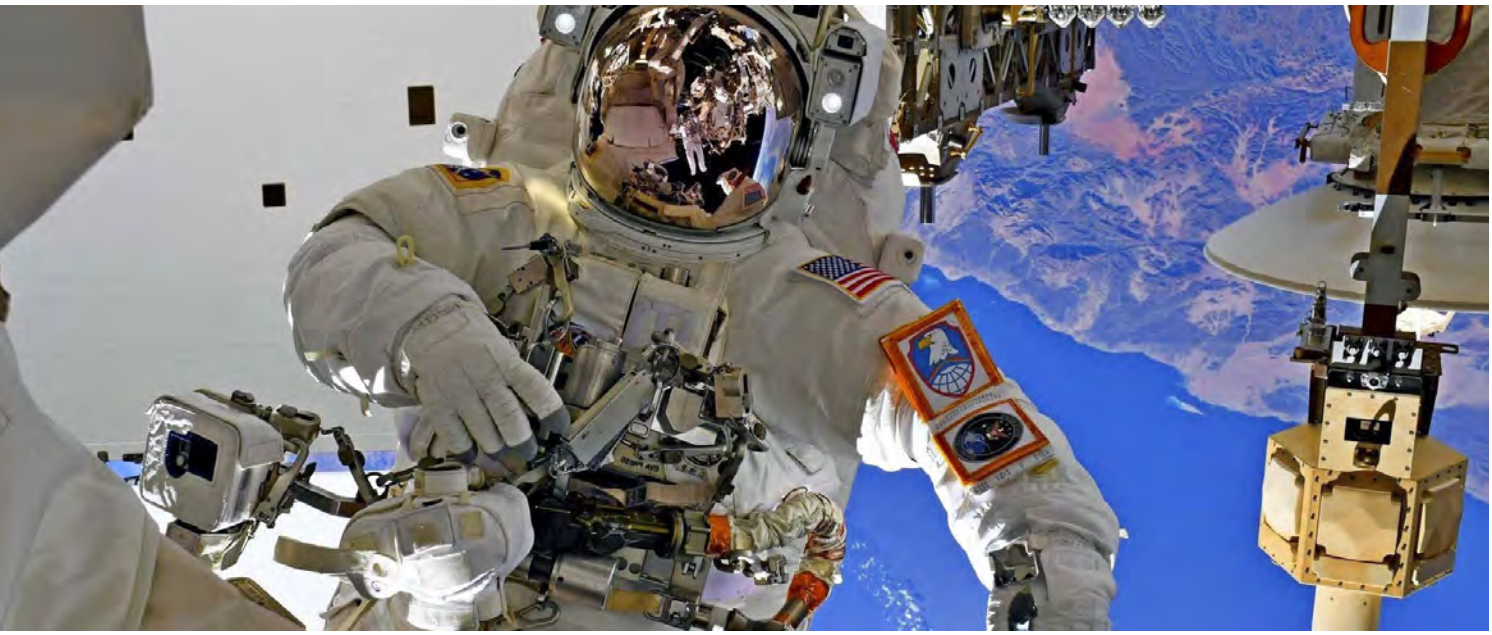
China's PLA Army (PLAA) is the world's largest standing ground force, with approximately 915,000 active-duty personnel in combat units. Recent structural changes to PLAA organization and tactics aim to develop more mobile and modular units. To assist in the transformation, the PLAA is also modernizing C4I systems to enhance its forces' interoperability. PLAA forces stress the importance of ISR and leveraging information to enable future combat.[29] In addition to its military modernization, China's growing economic power fuels its ability to compete with the U.S. across a broad industrial spectrum. China's gross domestic product has exponentially increased since 1992, at a growth rate double that of the U.S., and is now directly competitive with the U.S.[30,31] China's industrial policies and national priorities[32,33] are focused on advancement in areas that will enhance its soldier systems capabilities: quantum communications and computing; innovative electronics and software; automation and robotics; specialty materials; nanotechnology; batteries, power, and alternative energy; and neuroscience, neural research, and artificial intelligence.

Commercial Demand Dominance. DoD competition with commercial demand signals is a problem that impacts textiles, batteries, and night vision technologies, along with many other soldier systems industry subsectors. While commercial demand can provide stabilizing revenue to industry during periods of reduced DoD demand, it also reduces the DoD's influence on the market and ability to drive investment in the development of next generation technology.

Although access to the commercial market improves industrial base robustness, reliance on commercial products and innovation also contributes to the commercial market's role in driving demand. Furthermore, the DoD is not always the primary customer. When military and commercial requirements differ substantially, or if shared resources are scarce, commercial market dominance can directly impact lead time, surge capacity, and the sustainment or development of defense-unique industrial capabilities. Often DoD is left to adapt to commercial market-driven changes, and only when unacceptable levels of industrial base risks arise may DoD intervene in order to sustain critical industrial capabilities.

Operational Transition. The soldier systems sector is emerging from a long-term sustainment effort largely focused on fulfilling immediate warfighter needs. Many programs have met or are approaching their acquisition objectives, which triggers a natural peacetime cycle of decreased defense spending/ demand leading to industry consolidation, reduction in capacity, loss of capability, reduced capital investment, and a transition toward commercial investments for industry to remain viable.

Peacetime industrial readiness losses have historically been recovered or replaced by alternatives upon the United States entering another large-scale military engagement—as soldier systems become tailored to new conditions and operating environments. As the war efforts in the Middle East wind down, DoD and industry are pursuing some modernization efforts. Future soldier systems objectives include lightening the soldiers' load, capitalizing on lessons learned after years of fighting, developing modular/ flexible/agile materiel solutions, and taking advantage of advancements in sensor technology and materials engineering.



SPACE SECTOR

Sector Overview

The space sector is primarily driven by the commercial (foreign and domestic) market and includes satellites, launch services, ground systems, satellite components and subsystems, networks, engineering services, payloads, propulsion, and electronics.

Space systems provide an emergent capability and strategic advantage to U.S. forces. However, due to market trends, supply chain globalization, and high manufacturing costs, future access to space qualified domestic industrial sources, such as microelectronics and solar cells, is uncertain. Increasing cyber-threats, questionable (non-trusted) supply-chains, foreign acquisitions, pressure from lower cost imports backed by foreign subsidies, reliance on vulnerable foreign sources, and erratic demand threaten essential space capabilities and critical skills. This will result in a diminished or nonexistent domestic supply of qualified critical materials and components needed to support the National Security Space (NSS) space industrial base missions.

NSS increasingly leverages the commercial space industry; however, certain performance requirements and capabilities are particularly stringent, or unique, to NSS and require support outside of the growing commercial/civilian space ecosystem.

However, due to market trends, supply chain globalization, and high manufacturing costs, future access to space qualified domestic industrial sources, such as microelectronics and solar cells, is uncertain.

The Space Industrial Base Working Group (SIBWG)—comprised of government and industry stakeholders—assesses risks within the space industrial base, develops mitigation plans, and promotes management and procurement practices across the DoD and the

Table 10: Space Technologies

Space Technologies		
2015-2020		
– Hyperspectral sensors – Laser communications – Modularity – Sensors integration – Situational awareness – Survivability – Small/nano satellites – Electric propulsion – Additive manufacturing	– Survivability – Radiation hardened processors – Microelectronics	– Air launch systems – Fuel efficient liquid engines – Reusable equipment (1st stage) – Vertical take-off and landing (VTOL) – Additive manufacturing – Methane fuel engines – Heat shielding materials – New stainless steel
2020'S AND BEYOND		
– Alternative propulsion – Reusable equipment (entire rocket) – Single stage to orbit (SSTO) – Super heavy lift	– Nanotechnology – Improvements in autonomy, sensors, & artificial intelligence	– Larger satellites for some applications – Self-servicing and disposal – Clean-up and recycling of old/dead satellites

intelligence community (IC) to ensure access to technologies critical to the NSS community. SIBWG members actively assess and pursue risk mitigation efforts to proactively protect the U.S. space industrial base through cost-sharing contracts. Table 10 identifies a number of key technologies and issues for the space industrial base.

SIBWG Members:

- Air Force Space and Missile Center (SMC)
- National Reconnaissance Office (NRO)
- Missile Defense Agency (MDA)
- National Aeronautics and Space Administration (NASA)
- OUSD Industrial Policy

Major Risks & Issues

DoD and USG-wide studies and analyses have identified at-risk capabilities, fragile suppliers, and stress in the lower tiers of the space industrial base. The DoD space industrial base remains a niche market with very specialized and capital-intensive requirements that are not efficiently managed through individual program investments. Many systems in planning and development are relying on dated technology and skills, as well as fragile sources. Individual programs are reluctant to invest in, and qualify, new technology and sources. This creates a need to sustain fragile domestic sources and to qualify new technologies and sources for next-generation systems, which are essential to confront ever-increasing threats in the space domain.

Reliance on the commercial market provides many benefits to DoD including new technology sources; however, it also imposes sources of vulnerability.

The SIBWG currently tracks 119 essential space capabilities with identified supply chain risks. The three following technologies tracked by the SIBWG exemplify the types of risks impacting the space industrial base:

Primary Macro-Forces Driving Risk:

- Sequestration and Uncertainty of U.S. Government Spending
- Industrial Policies of Competitor Nations
- Diminishing U.S. STEM and Trade Skills

Precision Gyroscopes

Precision Gyroscopes are a critical component of the attitude determination, stabilization, and inertial navigation system on spacecraft, launch vehicles, and missiles. Three or more individual gyroscope inertial sensors are typically packaged in an internally redundant inertial measurement unit. Three types of gyroscopes (ring laser, hemispherical resonating, and fiber optic) are commonly employed in space systems, each with varying industrial base issues. Hemispherical resonating gyroscopes are an older technology mainly used on non-agile satellites and only one domestic provider remains—with limited production capacity. The fiber optic gyroscope is employed in high performance agile spacecraft and missile applications. While there are currently three domestic suppliers, fiber optic gyroscopes rely on key components - integrated optics chips and laser diodes – experiencing supply issues which threaten the viability of domestic product lines.

Space Qualified Solar Cells

Space qualified solar cells are highly efficient and optimized for specific space environments required for NSS and NASA missions. The optimization of these cells hinders the transfer of technology to terrestrial applications and often prevents providers from diversifying to reduce risk and burden. Advanced cells are under development to provide weight savings, decrease stowage footprint, and enable higher-power missions. Foreign suppliers are also aggressively developing high efficiency cells while marketing at lower costs to U.S. providers. Long-term procurement from U.S. providers is at risk, based on the foreign performance and price points. The loss of a U.S. solar cell provider and substrate provider is a real possibility if government funding is not made available, or policies are not put in place to protect capabilities. Providers face significant challenges to remaining competitive, depending solely on NSS procurement funding, whose batched orders are generally low volume, low margin, and with inconsistent demand.

Traveling Wave Tube Amplifiers (TWTAs)

TWTAs, comprised of an RF Vacuum Tube and an Electronic Power Conditioner, are required for improved RF spectrum access and larger bandwidth in military satellites. Some programs require a domestic source and recent commercial market downturn is imposing stress on business. Diminishing workforce skill is also a significant issue following recent layoffs in the Space TWTA business. A sole domestic supplier competes with a foreign source for all space qualified TWTAs, which leads overall with more competitive products and pricing. Having a strong domestic source would reduce dependence on the foreign source and ensure availability of NSS specific TWTAs.

The SIBWG recognized that effective space IB risk mitigation is best shared among enterprise partners where one can target investments at the most important elements and maximize efficiency of investments. The Department continues to synergize implementation of Space Industrial Base (SIB) risk mitigation efforts. Consistent with Titles 10 and 50

of U.S.C., which require inter-agency collaboration in industrial and supply base risk assessments and mitigations, DoD has renewed the existing NSS SIB Risk Management Program. The SIBWG, as an inter-agency working group, is addressing common requirements and challenges by leveraging technical expertise and cooperative funding to mitigate risks—in coordination with industry partners and joint investments. A coordinated strategy was established among MDA, OUSD(A&S)/Industrial Policy, AF, OGA, NASA and other agencies to subsidize and to reduce duplication of effort and other inefficiencies in the planned program executions for designated funding periods.

Notable Developments

United Launch Alliance's (ULA) Delta 4 Medium launch system flew for the last time in August 2019, around the same time that ULA's production facility in Decatur, AL began transitioning operations to Vulcan Centaur component production. These events indicate a healthier space industrial base reaction to emerging technologies and competition within the market.

In 2019, the U.S. Air Force also completed certification of the SpaceX Falcon Heavy launch system, which should reduce dependence on legacy heavy lift launch systems.

FY2019 Launches

Advanced Extremely High Frequency (AEHF) Space Vehicle-4 (SV-4) successfully launched on October 17, 2018 and completed on-orbit testing in April 2019. SV-4 is now fully integrated into the combined AEHF/Military Strategic and Tactical Relay (MILSTAR) constellation. SV-5 successfully launched on August 8, 2019.

Wideband Global SATCOM Satellite 10 (WGS-10) successfully launched on March 15, 2019 and completed contractor on orbit testing.

Global Positioning System III Space Vehicles 1 (GPS III SV01) successfully launched on December 23, 2018 and SV02 successfully launched August 22, 2019.

Sector Outlook

According to Euroconsult's Government Space Programs 2019 report, "civil programs are driving the world's space spending growth, totaling $44.5 billion in 2018, a 4.3% increase over 2017. The U.S. civil budget, growing at a 4% five-year compound annual growth rate (5Y CAGR), propelled by the expansion of its space science, technology, and human spaceflight programs, is a main force behind the global growth."[34]

In areas where commercial demand is insufficient or DoD-unique components exist, hard-to-reconstitute manufacturing processes must be maintained or improved to avoid schedule and cost impacts associated with re-establishment. Inter-agency collaborative investment, including from the SIBWG, is particularly effective for mitigating these types of risks. Despite several successful SIBWG investments over the past few years, additional risks continue to be identified.

One of the big thrust areas for the SIBWG in 2020 will be combining investment strategy with policy strategy in-order to provide stronger mitigation efforts. Policies under consideration include stronger direction to the industrial base to utilize secure and trusted sources when possible. The unique requirements of NSS require constant monitoring and more Government intervention than for typical defense industrial base sectors. Investment by individual programs tends to result in program specific architectures. Furthermore, cross cutting reviews of anticipated technology requirements must be conducted to maximize investment across space programs.

The Department must remain vigilant of sources of vulnerability, and maintain the critical capabilities specialized for military applications which typically require cutting-edge technology and have stringent requirements, but often deal in low production quantities when compared with commercial products.

MATERIALS

Sector Overview

The materials sector is among the most diverse assessed by the DoD. It begins with all elements of the Periodic Table, in their naturally extracted and synthetically-produced forms; then, it reaches down the supply chain through value-added processing, trading in intermediate forms, and manufacturing into semi-finished products acquired by the traditional sectors of the defense industrial base. This breadth of product coverage, global trade flows, and associated technical disciplines compels DoD to collaborate with numerous non-defense agencies and private industry, domestically and abroad, to ensure that the Materials Sector is adequately positioned to support the requirements of the National Defense Strategy.

The DoD largely relies on commercial markets and logistics networks to meet material demand. Since the close of the Cold War, reliance foreign sources and globalized processing operations has accelerated. In general, this trend has decreased the cost of materials and opened new sources to U.S. manufacturers, with concomitant growth in U.S. import reliance and offshoring across the sector. Notwithstanding this trend towards globalization, the DoD often maintains Government-unique procurement and supplier qualification regimes.

Direct demand for materials by the DoD in peacetime generally is a minor portion of total U.S. demand — frequently less than 1%. However, the vast majority of DoD consumption for materials occurs as indirect demand (i.e., materials embedded in or consumed in the production of an end-item). The substantial role of embedded demand in the U.S. market, as well as DoD procurement of commercial items and commercial off-the-shelf items, leads to an under-representation of defense requirements in demand estimates by statistical reporting agencies.

Major Risks & Issues

In alignment with the National Defense Strategy, the Department assesses risk to the materials sector at, and below, the level of Armed Conflict. Reduced to its simplest, the fundamental risk to the Department

within the materials sector is the *U.S. private sector capability gap* between today's globalized materials processing and logistics networks to (A) current threats below the level of Armed Conflict and (B) serious threats to the U.S. and allied defense industrial base in the event of Armed Conflict.

Below the level of armed conflict, the Department observes three broad risk archetypes. These risks are manifest in numerous ways to producers and suppliers within the Materials Sector.

Consolidation of Supply Chains in Ownership, Geography and Market access

Market-based producers often compete against non-market actors that benefit from low-cost debt finance, direct and indirect subsidies, state-driven supply mandates, and price discrimination. Though the Department plays an active role in reviewing foreign investment in the domestic materials sector, DoD is increasingly concerned by transactions in which equity ownership is accompanied by otherwise unannounced preclusive supply arrangements. Direct equity investments are amenable to tracking by regulatory bodies in the United States and those of our allies and partners, but off-take agreements often escape scrutiny, thereby masking the diversion of supply to peer competitors and stunting the growth of value-added materials processing by the U.S., its allies, and our partners.

Under-Executed or Lack of Due Diligence in Supply Chains

Limited visibility into supply chain tiers presents a significant challenge and risk to the DoD. DoD and its non-defense agency partners have observed illicit trade in materials, which has led to the proliferation of corruption, organized crime, and human rights violations. These factors undermine U.S. national security and that of our allies and partners. In the worst of cases, the Department and our non-defense agency partners have observed illicit trade in materials directly financing threats to the United States.

Lack of Resilience in Supply Chains

Numerous studies by the U.S. Government, foreign governments, private industry, and trade associations highlight U.S. reliance on sole-source suppliers and single points of failure within commercial and defense supply chains. The potential for supply disruption resulting from a force majeure event, or other business failure, poses substantial risk to DoD programs. Foreign control over large segments of material supply chains and logistic network nodes also can put DoD at risk of strategic, politically directed interference.

Armed Conflict Risk Assessment

The risk archetypes below the level of Armed Conflict expand as the Department considers the requirements of the National Defense Strategy. The DoD expects that the Materials Sector will face substantial supply-side and demand-side shocks in the event of a national emergency. As U.S. and allied defense acquisition and sustainment expenditure increase, production capacity at domestic, foreign, and sole-source suppliers may be stretched or exceeded; global distribution networks may be disrupted; and in specific cases, outright shortfalls of materials for defense and essential civilian industry may occur.

Economic and scenario-based modeling by the DLA Strategic Materials is invaluable to the U.S. Government to characterizing this risk. This work is the only regular, broad-spectrum stress test of defense and essential civilian supply chains undertaken by the Department.

Notable Developments

On July, 22, 2019, President Trump signed five Defense Production Act (DPA) Title III Presidential Determinations (PDs) to create, maintain, protect, expand, or restore domestic industrial base capabilities relating to the following: production of rare earth metals and alloys; separation and processing of heavy rare earth elements; separation and processing of light rare earth elements; production of neodymium-iron-boron rare earth

permanent magnets; and production of samarium-cobalt rare earth permanent magnets.

Sector Outlook

A series of significant resource constraints shape the Department's actions in the materials sector. In short, the Department's flagship industrial base programs are severely under-funded to the requirements, inhibiting the Department's ability to appropriately mitigate risk.

Recent PDs relating to materials and material processing provide opportunities to utilize the DPA Title III program to create or expand production capacity. However, current real dollar funding for the DPA program has dramatically declined since 2010-2012, as illustrated in Chart 21. Even if prior-year appropriation trends continued to the present ($185.8 million forecast for 2020 versus $62.6M appropriated), those funds still would be under-sized to the project finance and working capital requirements of a comparable investment by the private sector and those historically executed by the Department to mitigate materials sector risk — $1.9 billion for the tungsten industry alone, for example.[1]

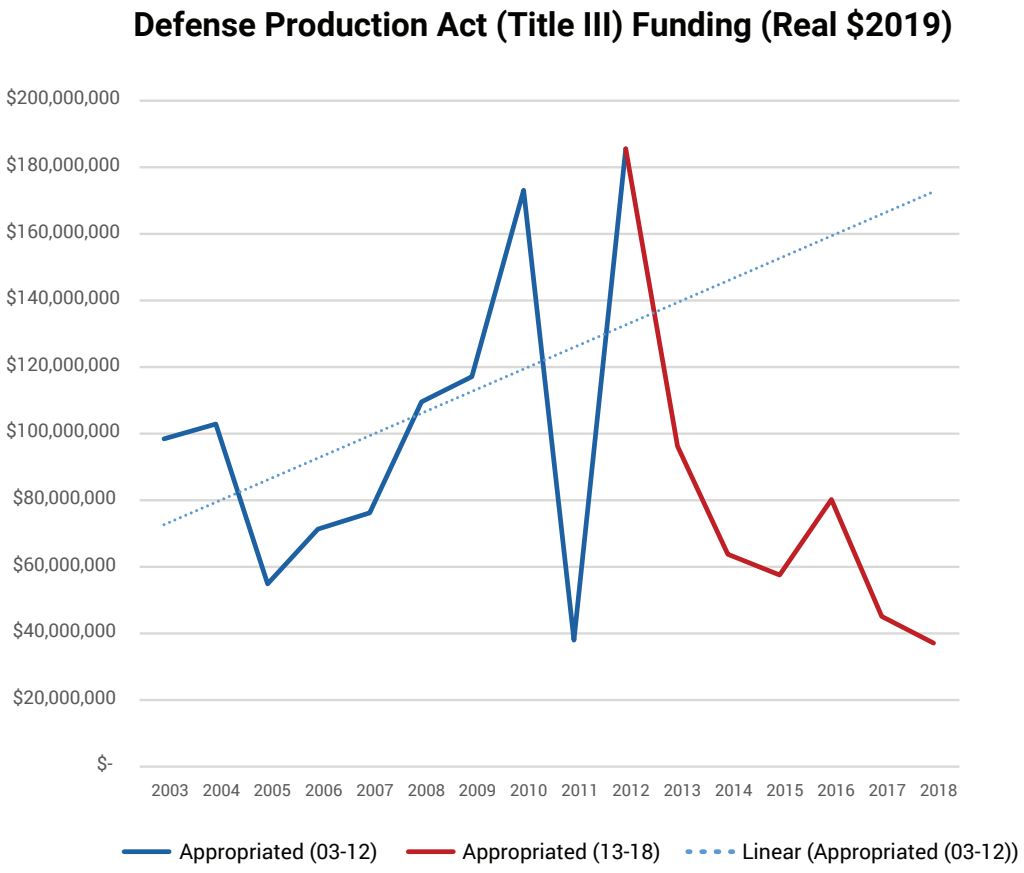


Chart 21

Another authority that can be deployed by the Department to meet Materials Sector requirements is the *Strategic and Critical Materials Stock Piling Act*. This statute provides for the procurement, recycling, and upgrade of strategic and critical materials by the National Defense Stockpile (NDS) Program. DLA Strategic Materials administers this program on behalf of the OUSD(A&S), via a revolving fund called the NDS Transaction Fund. As noted in the FY 2021 President's Budget Request, the resources of the NDS Transaction Fund are projected to be exhausted by FY 2025.

The funding deficit is driven by a combination of growing material requirements and legislatively-directed disbursements from the NDS Transaction Fund to other programs (see Table 11). From FY 2003 to FY2018, 89.8% of the proceeds from NDS Program activities, measured in real dollars, was diverted to other defense and non-defense programs, such as the Defense Health Program, construction of the World War II Memorial, and the Federal Supplementary Medical Trust Fund.

Table 11: National Defense Stockpile Transaction Fund Distributions

DISTRIBUTION TYPE	TOTAL AMOUNT (FY03–FY18) (REAL $2019)	AVERAGE ANNUAL CASH FLOW (REAL $2019)	SAMPLE ACTIVITIES / ACCTS.
To National Defense Stockpile Transaction Fund	$ 417.3M	$ 26.0M	– Material acquisitions – Qualification of new sources – Metallurgical R&D
To Non-Defense Accts.	($ 998.6M)	$ 62.4M	– General Treasury Acct. – American Battle Monuments Commission (World War II Memorial) – Hospital Insurance Trust Fund – Federal Supplementary Medical Trust Fund
To Other Defense Accts.	($ 2,701.5M)	$ 168.8M	– Foreign Military Sales Treasury Acct. – Reclamation purchases of electromagnetic spectrum – Defense Health Program – MILSVC Operations & Maintenance accts.
Net Cash Flow to National Defense Stockpile Transaction Fund	**($ 3,282.8M)**	**($ 205.1M)**	

[1] *See United States. Attorney-General., United States. Congress. Senate. Committee on Banking and Currency. (1957). Review of voluntary agreements program under the Defense Production Act: expansion of tungsten supply: report dated November 8, 1957. Washington, D.C.: U.S. G.P.O..*

In light of these constraints, DoD's approach to the Materials Sector is an exercise in economy of force. It deploys against our highest risk materials and aims to expend only just enough funding and acquisition authority to de-risk a given project that private sector capital can carry a project to the next phase of development, such as pilot-scale or low-rate initial production. Further to this approach, the Department is pursuing the following activities in the materials sector:

U.S. Interagency Collaboration

The Department continues to leverage the partnerships forged in the execution of EO 13806 and EO 13817 to implement joint solutions, including:

- Sharing modeling best-practices, data, and data analytics approaches
- Pooling research and development funding to address common risks
- Enabling of defense and non-defense agencies in domestic and international fora

The Department maintains valuable partnerships with the Departments of State, Commerce, Interior, and Energy, as well as the U.S. Trade Representative, the Overseas Private Investment Corporation, and the Executive Office of the President.

NTIB and Emerging Security Partner Collaboration

The Department has longstanding partnerships with Canada and Australia to meet defense requirements, bilaterally and via the NTIB framework. DoD is an active participant in multi-agency working groups with both Canada and Australia, which aim to identify and mitigate shared critical material vulnerabilities.

Modernization of Statutory Authorities for Materials Sector Mitigation

Major industrial base mitigation authorities for the Department of Defense generally date to the Korean War-era or earlier. Some of these authorities are regularly re-authorized, but others have not undergone a meaningful reassessment since the 1970s. As such, DoD intends to assess its current portfolio of industrial base mitigation authorities and may propose legislative recommendations for reform, notably for loan finance and back-up off-take agreements under the Defense Production Act and material release and acquisition authority under the *Strategic and Critical Materials Stock Piling Act*

Exercise the Authorities of the Strategic and Critical Materials Stock Piling Act and the IBAS Program

The Department has scored major successes via the NDS Program and IBAS, including:

- The qualification of a new, domestic source of carbon fibers to compete with sole-source, foreign-produced carbon fibers, and
- The development of a North American mine, with subsequent domestic metallurgical upgrading capability

The Department intends to continue these programs and integrate nascent U.S. and allied nation sources of materials to offset U.S. reliance on peer competitors, subject to the availability of funding.


LASH

CYBERSECURITY FOR MANUFACTURING

Sector Overview

The cybersecurity for manufacturing sector includes information technology and operational technology within contractor factories and across defense manufacturing supply chains.

Defense manufacturing supply chains consist of tiers of manufacturers of varying size and sophistication. Goods and critical information flow continuously within these supply chains and among diverse manufacturer organizations to transform raw materials into components, subassemblies, and ultimately finished products and systems to meet DoD performance specifications and requirements. Defense manufacturing supply chain operations rely on an infinite number of touch points where information flows through a network – both within and across the many manufacturers' systems that constitute the supply chains. Every one of these supply chain touch points represents a potential vulnerability to the security of our nation's defense production.

According to data released in late 2019 by the U.S. Census Bureau, approximately 291,000 manufacturing establishments operate in the United States.[35] Nearly 99% of those establishments are small and medium-sized manufacturers (SMMs) with fewer than 500 employees.[36] Multiple data sources indicate that most SMMs are unprepared to deal with a cyber attack. This problem is acute within defense manufacturing supply chains, where SMMs—often lacking basic cyber controls— constitute the bulk of the critical lower supply chain tiers.[37]

While many defense manufacturing supply chain operations occur in classified and tightly controlled environments, most information that is generated, stored, and exchanged in the DIB is not classified. The protection of such unclassified, covered defense information, or CDI (including controlled unclassified information (CUI)), presents an enormous and complex challenge and vulnerability. 35% of all cyber-espionage attacks in the U.S. are targeted at the manufacturing sector.[38] Most of the manufacturing data of interest to adversaries is essentially CUI. This includes design information; performance specifications; shop floor execution data; factory

support information (e.g., financials, system status, and personnel); and supply chain operational information (e.g., invoicing, pricing, and contract volume). As such, cybersecurity for manufacturing presents a persistent, widespread, and complex challenge to the entire DIB.

Sector Risks & Issues

Awareness and Wherewithal of Small Defense Contractors to Implement Cybersecurity Protections

Both the public and private sectors recognize the importance of safeguarding informational and operational assets from cyber risks. However, cybersecurity has not become an ingrained norm in manufacturing, especially in small and medium-sized manufacturers. Defense Federal Acquisition Regulations Supplement (DFARS) clause 252.204-7012 requires defense contractors and subcontractors to implement the information security protections described in the National Institute of Standards and Technology (NIST) Special Publication 800-171 Rev 1, "Protecting Unclassified Information in Nonfederal Information Systems and Organizations" by December 31, 2017. Interactions with several thousand small manufacturers by the Department of Commerce (DoC) Manufacturing Extension Partnership (MEP) National Network since 2017 reveals an lack of awareness and understanding of the DFARS cybersecurity requirement, and a deficiency of financial and technical resources necessary to manage cyber security risks. Compliance to the requirements by sub-tier suppliers, while increasing, remains relatively low and is not pervasive throughout defense manufacturing supply chains.

Gaps in cybersecurity protections among small defense manufacturers can lead to widespread and persistent vulnerabilities to the industrial base, contributing to the erosion of manufacturing and decreasing economic competitiveness and national security.

Cybersecurity risks impact all facets of manufacturing supply chain operations, from product and process data, to supply chain operations and logistics, to the reliability of tools and equipment used within manufacturing enterprises. Multiple approaches exist to manage cybersecurity risks within the industrial base, but not all approaches are appropriate or even adequate to meet the national security need to protect CDI and CUI. Three key issues – lack of uniform security implementation; inconsistent implementation of adequate security by defense suppliers; and reliance on self-attestation as indicated by current DFARS requirements – expose manufacturing to cybersecurity risks.

Three key issues- lack of uniform security implementation; inconsistent implementation of adequate security by defense suppliers; and reliance on self-attestation as indicated by current DFARS requirements–expose manufacturing to security risks.

Inadequate Focus on Manufacturing-Specific Cybersecurity Needs

Manufacturing is the most heavily attacked sector in the economy (after finance), and the defense industrial base is subject to continuous, coordinated cyber-attack campaigns by nation states. As new types of cyber threats and vulnerabilities targeting manufacturing supply chain-specific information and operational systems emerge, the U.S. cannot rely on small and medium-sized manufactures to protect against attacks from sophisticated nation state actors. Imposing stringent requirements on SMMs could even act as a deterrent for smaller commercial firms considering entering the defense market. Unfortunately, most cybersecurity research and development (R&D) is focused on information systems, without specific emphasis on the unique needs and operational technology (OT) aspects of the manufacturing sector.

If unaddressed, the industrial base faces a high likelihood of serious and exploitable vulnerabilities, while experiencing a reduction in the number of suppliers compliant with requirements and eligible to provide products and services to DoD. This combination of risks will impact both the resiliency of existing suppliers and the integrity of the supply chain.

Notable Developments

OUSD(R&E) executed two major efforts in 2019 to help secure the defense manufacturing supply chain, as described below.

OUSD(R&E), through the Manufacturing Technology Program, executed an Interagency Agreement with the DoC NIST Manufacturing Extension Partnership Program (MEP) for 2019 and 2020 to provide outreach, education, and technical assistance to small and medium-sized defense contractors via the MEP National Network™ of Centers—located in all 50 States and Puerto Rico. Through this effort, the MEP National Network is assisting defense contractors, with an emphasis on small to medium-sized manufacturers (SMMs), in implementing cybersecurity protections needed to safeguard CUI handled in defense manufacturing supply chains. The work is focusing on three primary tasks:

- Conducting outreach events to create awareness and educate defense contractors about the importance of cybersecurity in their operations;
- Providing small defense contractors with the technical assistance needed to ensure implementation of adequate security protections of CUI;
- Coordinating the application of Use Case Development and Implementation with NIST Laboratories to demonstrate the implementation of needed protections for manufacturing operational technology (OT) for cybersecurity.

The DoE Office of Energy Efficiency and Renewable Energy (EERE) issued a Funding Opportunity Announcement (FOA) in March 2019, in partnership with the DoE Office of Cybersecurity, Energy Security and Emergency Response (CESER), seeking to establish a Clean Energy Manufacturing Innovation Institute dedicated to advancing cybersecurity in energy efficient manufacturing. The Institute will pursue targeted research and development (R&D) focused on understanding evolving cybersecurity threats to greater energy efficiency in manufacturing industries, developing new cybersecurity technologies and methods, and sharing information and knowledge to the broader community of U.S. manufacturers.

DoE identified two major high priority challenge areas where collaborative R&D can help U.S. manufacturers remain resilient and globally competitive against cyberattacks: securing automation and securing the supply chain network. The Institute will leverage expertise from industry, academia, state and local governments, Non-Governmental Organizations (NGOs), non-profits and Federally Funded Research and Development Centers (FFRDCs). DoE began administering the competition for this Institute in 2019 and is targeting selection and initial operation in 2020.

In 2019, the Defense Industrial Base Sector Coordinating Council (DIB SCC) chartered and began operating a Supply Chain Cybersecurity Industry Task Force to identify, prioritize, oversee, and drive adoption of implementable solutions to protect CUI. The formation of this task force marks the continued evolution of information sharing and collaboration within the defense industry, but sharply focuses on supply chain cyber security activities and will serve as an on-going mechanism to drive improvements in DIB resilience. Task Force members include small, medium and large companies who form the DIB SCC. Founding members of the Task Force are BAE Systems, Boeing, Lockheed Martin, Northrop Grumman, and Raytheon. Initial focus areas include developing requirements focused on advanced persistent threat tactics, enhancing oversight and accountability, driving implementation of paradigm-changing approaches, and establishing enduring partnerships across industry and the DoD.

The DIB SCC serves as the primary private sector policy coordination and planning entity for the DIB to discuss cybersecurity, physical security, insider threat, and issues that affect the resiliency of the DIB. The

DIB SCC sustains the security, resilience, and critical infrastructure protection advances of the U.S. defense industry, both as an industry coordinating body within the DIB sector, and in partnership with the DoD as the designated Sector Specific Agency (SSA) for the DIB. The DoD's counterpart to the SCC is the DIB Government Coordinating Council (DIB GCC). The DIB GCC maintains relevant coordination with operational activities of the Federal government and other operational organizations via the National Defense Information Sharing and Analysis Center (National Defense ISAC), which supports the DIB SCC as the sector's information sharing, analysis, and operational mechanism.

Sector Outlook

The Office of the Undersecretary of Defense for Acquisition and Sustainment (OUSD(A&S)) recognizes that security is foundational to acquisition and should not be traded along with cost, schedule, and performance moving forward. OUSD(A&S) began working in 2019 with DoD stakeholders, University Affiliated Research Centers (UARCs), Federally Funded Research and Development Centers (FFRDC), and industry to develop the Cybersecurity Maturity Model Certification (CMMC), as described below:

- The CMMC will review and combine various cybersecurity standards and best practices and map these controls and processes across several maturity levels that range from basic to advanced cyber hygiene. For a given CMMC level, the associated controls and processes, when implemented, will reduce risk against a specific set of cyber threats.
- The CMMC effort builds upon the existing DFARS 252.204-7012 regulation that is based on trust by adding a verification component with respect to cybersecurity requirements.
- The goal is for CMMC to be cost-effective and affordable for small businesses to implement at the lower CMMC levels, and the intent is for certified independent 3rd party organizations to conduct audits and inform risk.
- Initial CMMC implementation is targeted for 2020.

In 2018, OUSD(R&E) established the National Center for Cybersecurity in Manufacturing at the Manufacturing times Digital (MxD) Manufacturing USA Institute in Chicago, IL. Since its launch, this center (known colloquially as "MxD Cyber), has operated as a testbed for the creation and adoption of cybersecurity technologies to secure manufacturing shop floors across the United States. MxD Cyber is working with partners across industry, academia, and government, to test cybersecurity use cases in a real-world manufacturing environment, and build upon the demos installed on its 22,000-square-foot manufacturing floor. It is developing hands-on cybersecurity training programs and creating online learning modules to serve the needs of smaller manufacturers nationwide. A Request for Proposals for cloud-based solutions for vulnerability assessments and penetration testing of manufacturing operations is open with a deadline in February, 2020. Solutions should be easy for SMM companies to deploy and maintain.

These initiatives will continue to address gaps in industry cybersecurity, through the development, dissemination, and implementation of best practices.

ELECTRONICS

Sector Overview

Electronics comprises the physics, engineering, technology, and applications related to the emission, flow and control of electrons in vacuum and matter. [39] The electronics sector manufactures products for a wide variety of end user markets, including consumer electronics, computers, automotive, industrial equipment, medical equipment, telecommunications, aerospace, and defense. Electronic systems and components are ubiquitous throughout all DoD weapons systems, but global military production represents only 6% of a market dominated by commercial devices.[40] While significant compared to overall worldwide military spending, total U.S. military spending on electronic systems in 2017 was insignificant compared to the overall aerospace and defense marketplace, as well as the commercial market, which gives DoD limited leverage over the direction of the industry.

Global military production accounts for only 6% of the electronics market

Printed Circuit Boards

Printed circuit boards provide the substrate and interconnections for various integrated circuits and components that make up an electronic system. Like the overall electronics market, the global printed circuit board market has experienced explosive growth – from $30 billion in 2000 to $60 billion in 2015.[41] However, this growth has mainly been driven by China, which now captures 50% of the global market share, while the U.S. share has reduced from 25% in 1998 to less than 5% in 2015.[42]

Microelectronics

Microelectronics is a subfield of electronics. As the name suggests, microelectronics relates to the study and manufacture (or microfabrication) of very small electronic designs and components. Usually, but not always, this means micrometer-scale or smaller. These devices are typically made from semiconductor materials. Many components of normal electronic design are available in a microelectronic equivalent. These include transistors, capacitors, inductors,

resistors, diodes,insulators, and conductors, which can all be found in microelectronic devices. Unique wiring techniques such as wire bonding are also often used in microelectronics because of the unusually small size of the components, leads, and pads. This technique requires specialized equipment and is expensive.

Microelectronic integrated circuits are the most technologically advanced level of the electronics sector. Since 1996, the global market for semiconductors has increased from $132 billion to $339 billion in 2016, with the Asia Pacific market outside of Japan accounting for the vast majority of this growth. The market quintupled in size from approximately $39 billion in 1996 to $208 billion in 2016, including a $107.6 billion market in China alone.

Asia, where much of the world's electronics production takes place, is also the largest customer base for U.S. semiconductor companies, accounting for approximately 65% of all U.S. sales, with sales to China accounting for slightly more than 50%. U.S. companies continued to hold a majority of the Chinese semiconductor market in 2016 with 51% share, marking a drop from 56% in 2015.[43]

Major Risks & Issues

Gaps in the electronics sector reduce the ability to deliver technological advantage in capability, performance, and reliability against adversaries. These gaps produce risks to the continued productivity and reliability of the U.S. electronics sector. In FY2019, at least four risks were paramount:

Decline of U.S. Printed Circuit Board (PrCB) Manufacturing Capabilities and Capacity

Micro-PrCBs are essential in the integrated circuit packaging vital to all electronic national defense systems. U.S. production of micro-PrCBs is lacking when compared to Taiwan, South Korea, Japan, and China who collectively produced over 90% of the $7 billion micro-PrCB production in 2015.[44] The United States produced less than .06% in the same year.[45] Asia remains the dominant force in the commercial PrCB assembly market with Hon Hai (Foxconn) standing at nearly eight times the size of the United States' largest PrCB assembly manufacturer, Jabil Circuit.[46] Since Asian facilities dominate the PrCB assembly market, they have also become the driving force for technical advances and investments in advanced assembly materials, equipment, and processes.

The United States lacks domestic capability to deliver production capacities of micro-PrCBs (organic substrates) used for integrated circuit packaging. Advancements in packaging technology will widen the gap between U.S. manufacturing capability and requirements for new technology in national defense system. U.S. companies' business models will not permit them to make the necessary investments to enter this evolving market due to the high labor costs, high capital investments, and the hyper-competitive environment created by Asia.

Capability gaps are compounded by limited investment in research and development (R&D) of advanced PrCB technologies for potential use in national defense systems. Without R&D focused on PrCBs for national defense systems, DoD risks losing its ability to ensure U.S. technological superiority.

There is a delay in the widespread adoption of newer technologies, likely caused by the resistance to adopt technology whose reliability is not fully proven.[47] There is also a demand to maintain decades-old technology and outdated materials to support legacy national defense systems, which will become fiscally insignificant compared to more profitable markets that demand advanced technology.

Deleterious U.S Government Business and Procurement Practices

U.S. purchases of PrCBs from non-trusted or unverified sources may have contributed to security or system integrity issues in major DoD programs.[48] [49] The absence of requirements to purchase PrCBs and interconnected products from certified or trusted sources may result in the introduction of faulty or malicious products being in DoD systems, has contributed to reduced domestic investments and capabilities, and created resiliency concerns within the PrCB supply chain.

This is in part due to policies and regulations that require or favor lower cost procurements, or COTS products, over trusted and verified procurements. Policies precluding or inhibiting lifetime buys of PrCB parts or components may result in downstream material shortages and integrity (trust) issues.

Industrial Policies of Competitor Nations

Made in China 2025, announced in 2015 by Chinese Premier Li Keqiang, is a state-led policy to develop domestic Chinese companies in order to gain control of global industries, including information technology, aerospace equipment, robotics, and electric vehicles. China has refrained from using the term "Made in China 2025" following the U.S. response to the plan's potential to disadvantage U.S. businesses and promote unfair trade practices. However, China continues to invest in the industries outlined in the policy.[50]

Diminishing U.S. STEM and Trade Skills

The U.S. workforce and knowledge of PrCB manufacturing is diminishing as baby boomers reach retirement age and U.S. PrCB manufacturing facilities lose more employees in technical and engineering specialties than they hire. The aerospace and defense industry's percentage of qualified STEM professionals aged 18-34 is under 20%, and the engineering and manufacturing industry ratio is similarly low.[51] Difficulty in filling and replacing the U.S. PrCB manufacturing workforce will worsen in the next decade, with estimates suggesting that 20,000 to 40,000 key positions will remain unfilled each year.

This predicted shortfall calculated against the Bureau of Labor Statistics reports of about 1,400,000 combined total employment in the Computer and Electronic Product and Electrical Equipment, Appliance and Component manufacturing subsets shows there will be a personnel shortage of about 2%-3%. In the professional areas of PrCB manufacturing (jobs usually requiring certification, or technical or college degrees), the top three difficulties in hiring were consistent: insufficient experience, insufficient technical education, and limited applicants, as shown below.

Of the 202 printed circuit board (PrCB) manufacturing facilities surveyed in the U.S. Bare Printed Circuit Board Industry Assessment 2017, 132 facilities anticipated challenges finding experienced employees, as shown in the following Table. Manufacturing facilities cite that roughly 522,000 jobs remained open in the sector in September 2019.[52] There are also limited formal education opportunities for electronic interconnect manufacturing in the United States.

PrCB Manufacturing Facilities Anticipating Staffing Issues[53]

Chart 22: Source: GP Ventures, "Mid-2019 PCB and EMS M&A Round-up," GP Ventures, 22 August 2019.

Notable Developments

Mergers and Acquisitions

Mergers and acquisitions are leading to a shrinking U.S. manufacturing base for PrCBs and interconnect technology, including numerous non-US buyers particularly affecting defense-qualified suppliers.

- Canadian-owned Firan Technology Group, Corp. (FTG) acquired Colonial Circuits, Inc. in July 2019. The acquisition provides FTG with a third U.S. location certified to MIL-PRF-31032.
- Summit Interconnect, Inc. (HCI) acquired Streamline Circuits, Corp.[54]
- United Technologies, Corp. and Raytheon Co. are consolidating.[55] Consolidations of larger companies like these create potential supply chain gaps by pushing PrCB bare board purchases to EMS companies.

While some mergers have diminished the U.S. manufacturing base for PrCBs and interconnect technologies, other mergers and acquisitions have increased electronics capacity and capability.

- TTM Technologies, Inc. announced its acquisition of PrCB assets from I3 Electronics, Inc. in June 2019[56] which may increase interposer and micro-PrCB capability in the United States.
- Cisco Systems, Inc. stated plans in July 2019 to acquire Acacia Communications, Inc., increasing its optical systems capability.[57] This will likely solidify the importance of cutting-edge optical component and module technology to networking hardware suppliers.

Technology

The Executive Agent for Printed Circuit Board and Interconnect Technology (PrCB EA) has made strides in the last year focusing on R&D to further PrCB technology development. These efforts have focused on Very High Density Interconnect, advanced packaging, and flexible-hybrid technology efforts leveraging Other Transactional Authority contract awards. These efforts reflect teaming among several Services and the NextFlex Manufacturing Institute along with organic investments in technical capability within DoD.

Academic Engagement.

Academic Engagement in the form of Cooperative Research and Development Agreements (CRADA) with multiple universities, collaborating with industry, and engaging with small businesses to innovate their manufacturing processes has also been a focus throughout 2019.

- Initiating a CRADA with Boise State University that will focus on advanced printed ink development, printed sensor devices, and printed energy storage/harvesting technologies.
- Initiating a CRADA with the University of Massachusetts – Lowell that will encompass developmental work related to additive electronics for technology protection.
- Exploring collaborative opportunities with Calumet Electronics to demonstrate semi-additive VHDI processes along with advanced packaging processes.
- Engaging with small businesses on the brink of transitioning their innovations to manufacturing

Outreach

Michigan Technological University in conjunction with industry leaders, NSWC Crane, and the PrCB EA developed and are offering a semester long course with curriculum dedicated to PrCB design and manufacturing, including hands on laboratory work.[58] Plans for similar programs are being discussed at the University of South Florida, San Jose State, Oregon State, and Washington State University.

To date, the PrCB EA has held ten Defense Electronics Supplier Roundtable discussions at industry events to engage with industry experts and continue to ensure U.S. warfighter superiority. These roundtable sessions provide industry experts with the opportunity to share concerns, questions, and suggestions with the PrCB EA and other government representatives. The roundtable sessions also allow the PrCB EA to share details on their recent accomplishments and projects with the industry.

Trusted Certifications

In order to establish more comprehensive trust assurance within the U.S. PrCB industrial base, DoD in partnership with IPC created IPC-1791; Trusted Electronic Designer, Fabricator and Assembler Requirements. These requirements serve to improve supply chain management, security, chain of custody, and quality assurance. There are currently ten companies certified to IPC-1791 and listed on IPC's Qualified Manufacturers List with several others preparing for the certification process.

Efforts to include provisions for the certification of non-U.S. PrCB designers, fabricators, and assemblers that are sponsored by U.S. prime contractors are currently underway. This will allow prime contractors to ensure that the foreign sources they rely on are trustworthy.

Sector Outlook

Demand for electronics and microelectronics will increasingly be driven by emerging capabilities and technologies. As such, "[t]here is a constant need by the PrCB industry for ongoing improvements in reducing size, weight and power, plus cost, which will provide opportunities to retool, shrink and redesign old legacy electronic systems from the PrCB up."[59]

The market for substrate-like PrCBs, also referred to as micro-PrCBs, is also growing, with an anticipated market of $2.6B by 2024 from $1.1B in 2018. Substrate-like PrCBs reduce space used on the PrCB, allowing for larger batteries and other components. Other advanced packaging methods designed to reduce space are also increasing in popularity. However, domestic production capacity for these technologies is extremely limited.

Advances in additive manufacturing will also have a significant impact on future production. 3D printed electronics, which is expected to be a $2B market by 2029,[60] will enable the creation of more compact PrCBs.[61] The market for smart materials, which can help detect atmospheric pressure changes, bio-chemical reactions, pH levels, humidity, among many other things useful for DoD applications, is expected to reach $98.2B by 2025.

Finally, hypersonic weapons and the concurrent need to supply ruggedized electronics to support these ultra-fast weapons will create new demands, especially as China and Russia continue to pour their own resources into this technology.[62] [63]

MACHINE TOOLS

Sector Overview

A *Machine tool* is a power-driven machine used to shape or form parts made of metal or other materials (i.e., plastics, composites) through processes including: turning, grinding, milling, stamping, drilling, forming, extrusion, injection molding, composite deposition, and various additive manufacturing techniques.

Modern machine tools leverage sophisticated industrial control systems, process parameter monitoring systems, and networked sensors. They also incorporate advanced materials and precision components, as well as advanced lubricants, bearings, sensors, and coatings. Machine tools provide the factory floor foundation for leveraging advances in robotics, high precision automation, specialty materials, precision components, and additive, subtractive and hybrid machining.

Machine tools support both prototyping and production operations, and their impact is felt across entire supply chains and industrial base sectors including transportation, aerospace, electronics, energy generation and distribution, and other critical infrastructure sectors. The global machine tool sector is very mature, and features fierce competition on price, features, and quality.

Major Risks & Issues

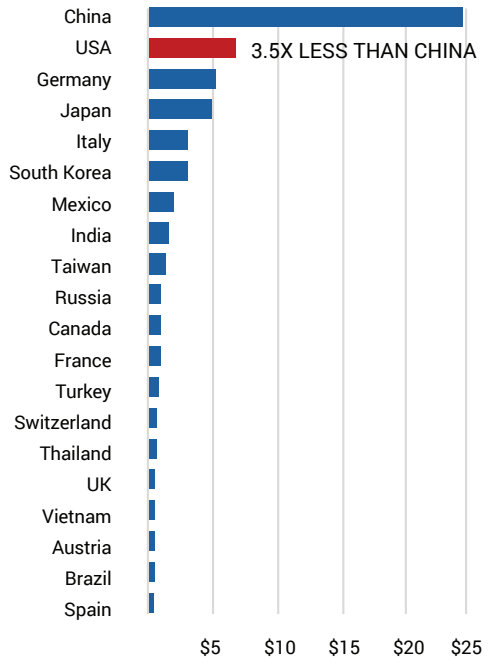
In FY2019, three risks were paramount to the Machine tools sector.

The U.S. machine tools sector continues to lose the capacity and diversity needed to support continuing innovation. In a business environment rife with low margins and fierce market competition, U.S. and friendly-nation firms are subjected to relentless economic tradecraft from competitors, especially China. Favored tactics include dumping, investments intended to influence or supplant corporate owners and leaders, predatory intellectual property and technical content rules, and theft of critical intellectual property— all executed or sponsored by nation states with vast capabilities and resources. As a result, U.S. defense and industrial capabilities increasingly rely on machine tools produced and potentially controlled by other nations.

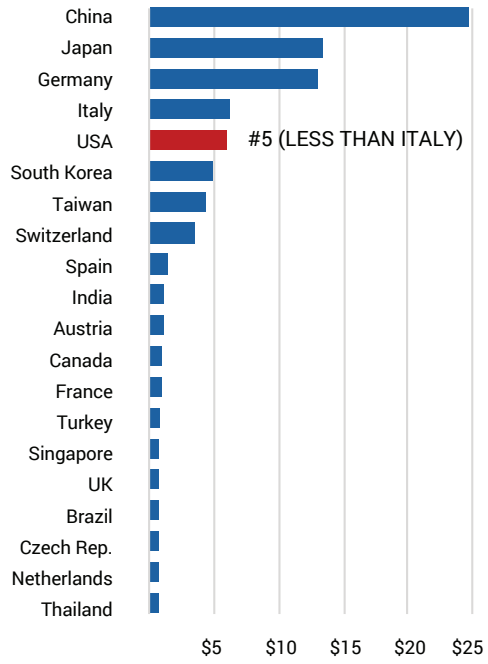
The U.S. lacks the robust, well-organized innovation ecosystem required to quickly produce revolutionary technological developments and transition them to factory floors. Few universities have large-scale industrial machine tool research programs, and cooperative efforts between industry and academia are lacking. Immediate, national-level action is required to correct this trend.

The U.S. machine tools sector lacks an assured supply of skilled labor to meet current and projected needs. Members of the vast "baby boomer" generation are increasingly leaving the workforce, and new workers with the requisite skills and abilities are in short supply. A key reason for this is that the U.S. lacks a robust, high-volume technical education system.

Moreover, parents and school officials continue to emphasize attendance at four-year colleges (regardless of the subject pursued) as the best path for the vast majority of students—even those whose aptitude for and interest in manufacturing-related subjects far outstrips their abilities in others. Without concerted action to provide a ready workforce and a continuously-charged pipeline of new employees, the U.S. will not be able to maintain the large, vibrant, and diverse machine tools sector needed to produce the quantity and types of products when needed.



Top 20 machine tool consumers in 2017



Top 20 machine tool producers in 2017

Chart 23: Source: World Machine Tool Survey

U.S. machine tool firms face a less-than-level playing field. U.S. machine tools are subjected to a combination of aggressive competitive policies and well-funded, highly effective economic tradecraft executed by other states and alliances. China's record of intellectual property theft via a combination of cyber intrusion and old-school espionage—including pressure tactics applied to both students and workers of Chinese descent—is well documented.

Individual nations and entire trade blocs have implemented coherent investment plans and tax policies to support their own industrial sectors, putting U.S. suppliers at a disadvantage. Examples include Made in China 2025 and the European Union's Investment Plan for Europe[64] and InvestEU Programme (2021-2027).[65] Finally, our industries also have to navigate the requirement of multilateral export controls, as regulated by the Department of Commerce.

According to the Gardner World Machine Tool Survey 2018,[66] the U.S. is second largest machine tool consumer ($8.51 billion/year). China is 3.5 times higher ($29.7 billion/year). The U.S. is fifth largest machine tool producer ($5.84 billion/year). China is 4.4 times higher ($25.42 billion/year). Machine tool production also correlates with trade deficits. The U.S. has the second largest deficit (-$2.666B) while Japan has largest surplus (+$7.140B).

"Nations that cannot make cannot innovate"

Machine tools are the foundation of national competitiveness across most manufacturing sectors. A well-known truism says "nations that cannot make cannot innovate." Without the ability to design, make, and employ advanced machine tools, a nation is at the mercy of others for critical capabilities. Moreover, continuing failure to meet the need for a well-educated domestic manufacturing workforce impedes U.S. progress in machine tool development and application.

the U.S. is the **second largest** machine tool consumer ($8.51 billion/year). China is **3.5 times higher** ($29.7 billion/year).

Notable Developments

As part of its strategy to promote, accelerate, and elevate the capabilities and workforce underpinning U.S. manufacturing, the IBAS program is working with Oak Ridge National Laboratory on a Phase 0 study focused on three lines of effort:

1. Lower machine tool market barriers to entry for small and mid-sized enterprises
2. Support and conduct development of advanced machine tools
3. Develop and deliver curricula and training to improve and expand machine tool-related skills of current manufacturing workers; and train the machine tool workforce of the future

The plan envisions a nationwide-network of regionally focused machine tool hubs. This network will focus efforts on developing required capabilities (i.e., digital skills, metrology skills, complex machining, specialty trades skills, and ability to work in hybrid manufacturing environments) and increasing the prestige of manufacturing as a profession in order to inspire more prospective workers to choose it as a career. The first hub will work to: increase the productivity of existing industry systems; develop and test the foundational knowledge required to produce large scale hybrid manufacturing systems and processes; and develop a strategic vision and application framework for the future advanced machine tools workforce.

Sector Outlook

According to International Trade Center data, the top five machine tool producers (excluding China and the U.S.) increased exports to China by $192 million, while decreasing their exports to the U.S. by $126 million. The difference is attributable primarily to builders in Japan and Taiwan. More high-end Japanese machine tools went to China than U.S.

This issue directly threatens U.S. national self-determination in commerce and geopolitics. At the same time that a principal adversary effectively cornered the market for critical raw materials, components, and finished products, the U.S. lost its formerly pre-eminent position as the world's leading machine tool consumer, producer, and innovator.

To compete and prevail in the modern world, the U.S. must have a robust domestic machine tools sector (that includes the design, production, and sale of common and advanced machine tools), as well as a large domestic machine tool user base supporting a vibrant manufacturing sector. However, corporate margins in the machine tool industry will not support the persistent level of investment required to support the timely development and adoption of key next-generation (and beyond) machine tool manufacturing capabilities that will be critical to the production of future national capabilities.

In the absence of immediate corrective action like the national network described above, observed trends are likely to accelerate as the macro forces create an accelerating "vicious circle." Clustering diverse sets of researchers, producers, suppliers, students, and end users through a centralized hub enhances innovation. Concerted action will help keep the U.S. from losing control of the scale, scope, velocity, and quality of critical defense and commercial production.

ORGANIC DEFENSE INDUSTRIAL BASE

Sector Overview

The organic defense industrial base (OIB), also known as the organic base, or the government or public sector industrial activities, includes GOGO and GOCO facilities that provide specific goods and services for DoD. The organic defense industrial base is comprised of resource providers, acquisition and sustainment planners, and manufacturing and maintenance performers, as well as depots, shipyards, manufacturing arsenals, and ammunition plants.

Collectively, the OIB provides maintenance and manufacturing services to sustain approximately **330,150 vehicles, 239 combatant ships,** and **over 14,800 aircraft.**

Table 12: Manufacturing Arsenals and Major Depot Maintenance Facilities

Organic Manufacturing Arsenals and Major Depot Maintenance Facilities	
Army – Anniston Army Depot, Anniston, AL – Corpus Christi Army Depot, Corpus Christi, TX – Letterkenny Army Depot, Chambersburg, PA – Red River Army Depot, Texarkana, TX – Tobyhanna Army Depot, Tobyhanna, PA – Rock Island Arsenal, Joint Manufacturing and Technology Center, Rock Island, IL – Watervliet Arsenal, Watervliet, NY – Pine Bluff Arsenal, Pine Bluff, AR	**Marine Corps** – Marine Depot Maintenance Command, Albany Production Plant, MCLB Albany, GA – Marine Depot Maintenance Command, Barstow Production Plant, MCLB Barstow, CA
Air Force – Ogden Air Logistics Complex, Hill AFB, UT – Oklahoma City Air Logistics Complex, Tinker AFB, OK – Warner Robins Air Logistics Complex, Robbins AFB, GA	**Navy** – Fleet Readiness Center East, MCAS Cherry Point, NC – Fleet Readiness Center Southeast, NAS Jacksonville, FL – Fleet Readiness Center Southwest, NAS North Island, CA – Portsmouth Naval Shipyard, Portsmouth, ME – Norfolk Naval Shipyard, Portsmouth, VA – Puget Sound Naval Shipyard and Intermediate Maintenance Facility, Bremerton, WA – Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility, Pearl Harbor, HI

Table 13: Software Engineering Activities

Software Engineering Activities	
Army	**Navy**
– Combat Capabilities Development Command Armament Software Engineering Center; Picatinny Arsenal, NJ. – Combat Capabilities Development Command Aviation and Missile Center Software, Simulation, Systems Engineering and Integration Directorate; Redstone Arsenal, AL. – Army Communications-Electronics Command-Software Engineering Center, Aberdeen, MD • Detachment, Ft. Sill, OK • Detachment, Ft. Huachuca, AZ – Tank Automotive Research, Development and Engineering Center- Software Engineering Center, Detroit Arsenal, MI	– Naval Air Warfare Center Weapons Division, China Lake, CA – Naval Air Warfare Center Weapons Division, Point Mugu, CA – Naval Air Warfare Center Aircraft Division, Naval Test Wing Atlantic, Patuxent River, MD – Naval Air Warfare Center Aircraft Division, Lakehurst, NJ – Naval Air Warfare Center Weapons Division, Training Systems Division, Orlando, FL – Naval Surface Warfare Center, Crane, IN – Naval Surface Warfare Center, Corona, CA – Naval Surface Warfare Center, Dahlgren, VA – Naval Surface Warfare Center, Indian Head, IN – Naval Surface Warfare Center, Panama City, FL – Naval Surface Warfare Center, Newport, RI – Naval Surface Warfare Center, Keyport, WA – Space and Naval Warfare Systems Command Systems Center Pacific, San Diego, CA – Space and Naval Warfare Systems Command Systems Center Atlantic, Charleston, SC
Air Force	
– Ogden Air Logistics Complex, Hill AFB, UT – Oklahoma City Air Logistics Complex, Tinker AFB, OK – Warner Robins Air Logistics Complex, Robbins AFB, GA	

Collectively, the OIB provides maintenance and manufacturing services to sustain approximately 330,150 vehicles, 239 combatant ships, and over 14,800 aircraft. Of $670.6 billion total DoD expenditures in FY2018, $86.4 billion was for maintenance. Aircraft represented the greatest expenditure at $34.7 billion, followed by ships at $16.2 billion, common equipment at $9.1 billion, and vehicles at $7.4 billion. DoD currently operates 17 major organic depot maintenance facilities and three manufacturing arsenals. The services provided within the OIB can range in complexity from daily system inspection and maintenance, to the complete depot-level overhaul or rebuild of weapon systems.

Congressional Requirement

By law, some production and maintenance activities must be executed by organic defense industrial base activities. Congress developed an extensive set of statutes that governs the maximum workload amounts, initial depot source of repair assignments and subsequent movement of workloads.

– **U.S. Code Title 10 §2464:** requires that "the Department of Defense maintain a core logistics capability that is Government-owned and Government-operated (including Government

personnel and Government-owned and Government-operated equipment and facilities) to ensure a ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situations, and other emergency requirements."

- **U.S. Code Title 10 §2466:** "Not more than 50 percent of the funds made available in a fiscal year to a military department or a Defense Agency for depot-level maintenance and repair workload may be used to contract for the performance by non-Federal Government personnel of such workload for the military department or the Defense Agency. Any such funds that are not used for such a contract shall be used for the performance of depot-level maintenance and repair workload by employees of the Department of Defense."

This government-owned ecosystem includes expertise to perform deep repair, the means to provide repair parts to the shop floor, and the ability to deliver repaired systems to the time and place of the fight. While commercial industry is the dominant component of the DIB, the organic defense industrial base acts as an insurance policy and exists to ensure a ready and controlled source of technical competence and resources. This supports an effective and timely response to contingency scenarios, and surge requirements. The OIB also acts as a buffer against many of the economic vulnerabilities and influences that exist in the private sector and has allowed for the development of highly capable depot capabilities.

Major Risks & Issues

20 years of intermittent conflict have driven high operating tempos, and unprecedented system usage have challenged previously accepted formulas used to compute maintenance requirements. The levels of funding, and the manner in which funding has been made available and allocated to sustainment operations, have further degraded our ability to achieve expected performance results. Materiel readiness levels and facility condition indices demonstrate the effects of overuse and underfunding.

Workforce issues have been exacerbated by sequestration, a shortage of skilled labor, and gaps in hiring. Diminishing manufacturing sources and material shortages, the introduction of counterfeit parts, and reliance on foreign manufacturing and single sources of supply represent further risks to the ability of the organic industrial base to influence materiel readiness.

These issues directly impact the ability to repair equipment and materiel as quickly as possible and ensure its availability for training and future deployments. The case studies below illustrate the need to ensure continuity of operational readiness during times when the private sector may not be able to meet surge requirements. The DoD is addressing these deficiencies, but they have been a long time in developing and will take time to resolve.

Deficiencies in Maintenance Facility Material Condition

A lack of available and effective capacity within government-owned industrial activities, coupled with a high near-term workload, has produced a capacity-to-workload mismatch. This mismatch continues to drive maintenance delays and an increased loss in operational days.

The current framework for organic infrastructure investment authorizes most DoD industrial activities to self-recapitalize by building an investment allowance into rates charged to their customers. Pressure to provide more readiness within constrained O&M budgets often conflicts with this authorization. In many cases, this conflict results in leadership decisions to allocate more resources towards immediate weapon system readiness, and less towards maintaining the infrastructure where related maintenance occurs. Therefore, military construction, capital investment, technology refresh, and facility modernization programs have lagged – resulting in deficiencies in maintenance facility materiel condition. Section 2476e of Title 10, United States Code, established minimum investment requirements for the military departments' depots, but as is evident, this is simply not enough.

Language contained in the NDAA for FY2019, directs the Secretary of Defense to deliver a comprehensive strategy to the congressional defense committees, no later than October 1, 2020, for improving the depot infrastructure of the military departments with the objective of ensuring that the depots have the capacity and capability to support the readiness and material availability goals of current and future DoD weapon systems. The provision requires that the strategy include a review of the current conditions and performance of each depot, a business-case analysis comparing the minimum investment necessary required under Section 2476e of title 10, United States Code, with the actual investment needed to execute the planned mission and a plan to improve the conditions and performance utilizing this data. The Department is in the process of developing this report and will comply with that direction. The Department remains committed to the implementation of common performance metrics developed by a Logistics Reform Team that, when finalized and applied, will quickly identify barriers to achieving facility-related cost and schedule metrics.

Maintenance

DoD operates many of its weapon systems well beyond their original designed service lives. Coupled with increased operating tempo and exposure to harsh environmental conditions, these platforms require engineering and overhaul processes far more extensive than those performed under historical organic industrial base infrastructure alignments. The infrastructure has not been refreshed to adequate levels of repair and technology modernization.

Most organic industrial base depots are working capital funded activities [this is not the case for Navy shipyards, which are direct mission funded] and required to reinvest and recapitalize equipment and facilities through their rate structure. Sensitivity to rate increases that are passed downstream into Service O&M budgets constrains each depot's ability to modernize and restore infrastructure to the extent required to preserve effectiveness and improve efficiency. While DoD's budget replaces and refurbishes plant equipment, and statute and policy direct follow-through on recapitalization, infrastructure investments have not been adequate to keep pace with commercial best practices and modern repair technologies. Without increased investment, the organic industrial base will remain challenged by outdated equipment, tooling, and machinery. The erosion of organic infrastructure continues to impact turnaround time and repair costs of both legacy and newly fielded weapon systems, reducing inventory, decreasing operational readiness, and impacting future deployment schedules.

Workforce Recruitment, Retention, and Onboarding

The DoD maintenance enterprise faces workforce skill gaps across the board. The emergence of new weapon technologies, coupled with retirements, has caused a significant mismatch between skill requirements and workforce capabilities. Recruitment and retention of critical skill sets are concerning, partially because of sharp competition for labor with the private sector and a lack of defense-specific skills. Training the new workforce is essential, and improving the organic industrial base's opportunity to recruit already-trained artisans would have significant and immediate impacts on productivity and readiness.

Exacerbating workforce issue is the lack of policy to authorize security clearance "transfer in status" when technicians who have clearances are hired; the statutory requirement outlined by 5 U.S.C. 3326 prohibiting the hire of military technicians for 180 days after separating from the military; and government shutdowns and furloughs, which diminish the ability to recruit, hire, and retain talented STEM personnel. In order to mitigate the time required to hire depot personnel, each of the Services have implemented the direct hire authority provided by Congress.

In addition to the activities mentioned above, several ongoing and interrelated mitigation strategies and initiatives are underway within DoD to address critical needs within the Department's organic industrial base. These efforts will help ensure the organic industrial base provides legislatively directed repair capabilities as well as continuity of operational readiness to meet unanticipated surge requirements.

Notable Developments

In FY2019 Congress passed legislation granting direct hiring authority to the services, which enabled the Army "to process 3,560 personnel actions during 2019," and has reduced "hiring time from 114 days to 85 days."[67] The Air Force has also benefited from the direct hiring authority, accounting for 74% of all Air Force hires in FY2019. These workforce expansions have supported increased workload resulting from high operational tempos and maintenance backlogs.

The Navy's public shipyards have experienced a 25% increase in planned work since 2010. In response, the Navy increased the size of its workforce by more than 9,000 people in its public yards.[68] However, given the rapid expansion, a large percentage of the workforce has less than five years of on-the-job training and cannot immediately meet skills requirements. Shipyards are transforming workforce training through learning centers that apply both virtual and hands-on training opportunities. These learning centers have reduced training time by more than 50%.

The OIB is also modernizing infrastructure for future requirements. In 2019, the Air Force opened the first hanger dedicated to KC-46 maintenance.

Sector Outlook

Each of the services has long-term plans for their organic capabilities to support current systems, improve readiness levels, and prepare for future requirements.

- Army: Organic Industrial Base Revitalization Strategy Implementation Plan.
- Air Force: Master Plan for Organic Industrial Base Infrastructure
- Navy: Shipyard Infrastructure Optimization Plan
- Marine Corps: Organic Industrial Base Modernization Plan

Although the services have noted improvements in manning, and maintenance throughput, the OIB remains reliant on aging equipment and infrastructure. The Army has already invested more than $1 billion in the last ten years to update depot facilities and predicts it will require $8.3 billion in additional military construction and modernization funds to fully re-capitalize. In order to optimizing depot infrastructure, the Air Force has also stated it will require resources above current thresholds.

In addition to maintaining legacy systems, the OIB is also preparing for the delivery and sustainment of new platforms. The Army is aligning its infrastructure investments with Army Futures Command, and prioritizing projects for GOCO/GOGO facilities. The Air Force has also continued to expand infrastructure in support of the F-35 and has begun preparations for support to the B-21 Raider aircraft.

Modernization

The OIB is beginning to adopt new technologies and practices to improve life cycle management, including predictive analytics and additive manufacturing.

Predictive analytics. Predictive analytics can inform supply forecasting and recommend maintenance actions, thereby avoiding unscheduled maintenance resulting from equipment/system failures, improving equipment availability and readiness levels, and reducing costs.

Additive manufacturing (AM). The Office of the Inspector General found that "81 Military Service depots, maintenance facilities, and field locations have used AM to produce thousands of AM parts and tools, such as cooling ducts, clips, and wrenches, to decrease maintenance time, reduce the impact of obsolete parts that are no longer available through traditional manufacturing sources, and improve existing parts."[69]

These practices can help to minimize supply disruptions and improve mission-capable rates across the fleet. A strong organic industrial base is key to maintaining critical skillsets and generating higher levels of readiness. Adequate and consistent funding can help the OIB modernize its practices, recapitalize aging infrastructure, compete for talent, and increase efficiency to provide support for the military when and where it is needed.

SOFTWARE ENGINEERING

Sector Overview

Software engineering is the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software. Software engineering capability includes the processes, resources, infrastructure, and workforce competencies to enable systems to meet operational mission requirements and evolving threats. Challenges within this sector have evolved significantly over the last several decades as the demand for engineering professionals and the DoD policy and processes for software failed to keep pace with the current and future digital transformation of the modern battlefield.

Software is in virtually every piece of electronics in the form of firmware, operating systems, and applications. This includes DoD weapon systems, mission support systems, maintenance systems, business systems, etc. Today's modern weapon systems rely heavily on software to provide functionality. As an example, the F-35 is estimated to rely on software for 90% of its avionics specification requirements. This has grown significantly over the last four decades when the F-15A had just 35% software reliance in 1975.

Unlike physical hardware, software can be delivered and modified remotely, greatly facilitating rapid adaptation to changes in threats, technology, mission priorities, and other aspects of the operating environment. Unfortunately, software for many weapon systems is being sustained with processes developed decades ago for hardware-centric systems. In addition, much of DoD policy remains hardware-centric, despite software providing an increasingly larger percentage of system functionality. In today's fast-paced, changing environments with mounting cyber threats, software engineering for software-intensive systems should

Software for many weapon systems is being sustained with processes developed decades ago for hardware-centric systems.

utilize agile software development methodologies and development, security and operations (DevSecOps) processes, and apply contracting practices capable of rapidly delivering incremental and iterative changes to the end-user.

Sector Risks & Issues

Since software is pervasive throughout military systems and technologies, the impacts within the software engineering industrial base manifest themselves across the traditional sectors. The Software Engineering Working Group that contributed to the September 2018 Interagency Task Force response[72] to Presidential EO 13806,[73] assessed impacts across sectors; as such, software risks are included in each of the sectors' inputs.

Diminishing U.S. STEM skills, and U.S. government business practices and policies are both driving risk within the software engineering industrial base that have defense-wide impacts.

Government Practices & Policies

Policy, roles, and responsibilities for software engineering at the DoD level are not clearly established to effectively represent software equities at the acquisition policy and program levels. The DOD lacks a unified software engineering policy, which has produced inconsistency in practices and policy implementation across the services. Despite its prevalence, engineering sustainability of software-intensive systems during the requirements, design, and development processes has also received limited focus and priority. Collectively, these factors have negatively impacted the successful development and sustainment of software across the department.

The DOD has also struggled to track and manage its inventory of software, which is immense and continually growing. There is limited visibility and understanding at the enterprise level of the total size, complexity, and characteristics of the inventory, which may exceed one billion lines of custom developed software code. A unified source of clear software engineering policy would aid in a unilateral implementation of appropriate practices across the industrial base.

STEM Workforce

Exacerbating the need to strengthen organic software expertise is the issue of a national STEM shortage. Today's education pipeline is not providing the necessary software engineering resources to fully meet the demand from commercial and defense sectors, and resources required to meet future demands continue to grow.

STEM covers a diverse array of professions, from electrical engineers to researchers within the medical field, and includes a range of degree levels from bachelor's to PhD. Seven out of ten STEM occupations were related to computers and information systems, with nearly 750,000 of them being software developers. Demand across all STEM sectors is not consistent; there is a surplus of PhDs seeking positions as professors in academia while there is a shortage of individuals with electrical engineering PhDs who are U.S. citizens.[74]

The development and sustainment of increasingly complex software-intensive weapon systems requires skills from both the engineering and computer science fields. The STEM shortage cannot be addressed solely by hiring more computer programmers. Modern software-intensive systems rely a great deal on skilled software system engineers with in-depth knowledge of the systems and environments in which the software operates (e.g. avionics systems, electronic warfare, weapons and space systems). The intersection of these disciplines creates a specialization which results in a limited resource pool when compared to the requirements of commercial software application developers.

Between 2014 and 2024, job openings are projected to exceed one million for computer occupations and half-a-million for engineers.[87]

The STEM shortage is even more challenging for the defense industrial base which requires most employees to obtain security clearances, necessitating U.S. citizenship. Students on

temporary visas in the U.S. have consistently earned 4%-5% of bachelor's level STEM degrees. In 2015, these students earned a substantially larger share (11%-13%) of bachelor's degrees in industrial, electrical and chemical engineering. The number of STEM bachelor's degrees awarded to students on temporary visas increased from about 15,000 in 2000 to almost 33,000 by 2015.[86]

The U.S. is also graduating less students with STEM degrees as a percentage of population compared to China, and the trend continues to worsen. The population of China is four times the population of the U.S. but is producing eight times the number of STEM graduates. The U.S. no longer has the most STEM graduates worldwide and is being rapidly outpaced by China. In 2016, the U.S. had the third most STEM graduates worldwide with 67.4 million graduates compared to China with 78.0 million.

The software engineering crisis in the defense industrial base will not be corrected until significant effort is placed on updating software policy and processes, and more importantly placing significant investment in software engineering education and retention initiatives. Greater attention must be paid to addressing workforce concerns in the Software Engineering sector in order to maintain and develop the intellectual capital necessary to create and sustain war-winning weapon systems for the modern battlefield.

S&E first university degrees, by selected region, country, or economy: 2000–16

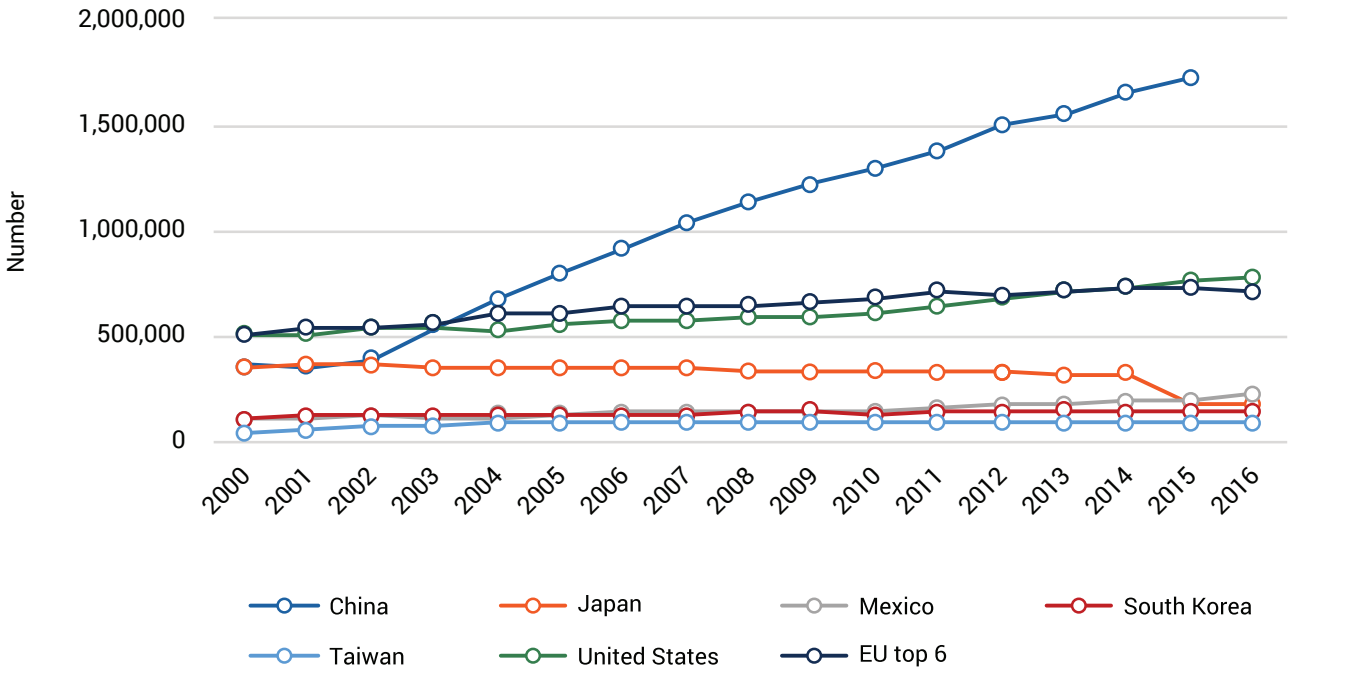


Chart 24: Organisation for Economic Cooperation and Development (OECD), Eurostat Education and Training Database, Science and Engineering Indicators (NSB-2019-7)

The population of China is **four times** the population of the U.S. but is producing **eight times the number of STEM graduates**.

Notable Developments

In May 2019, the Defense Innovation Board released a report, *Software is Never Done: Refactoring the Acquisition Code for Competitive Advantage,*[75] resulting from the Software Acquisition and Practices (SWAP) study. The congressionally mandated study (NDAA 2018, Section 872) outlines the importance and pervasiveness of software in modern DoD systems and emphasizes the need to decrease cycle time and develop digital talent, and the enduring qualities of software that differentiate it from the hardware paradigm. Implementation of the lines of effort recommended by this study is currently underway. In a memorandum released in October 2019, the Under Secretary of Defense for Acquisition and Sustainment, Hon. Ellen M. Lord, released interim policy and guidance on establishing direction, responsibilities, and procedures for the management of the Software Acquisition Pathway (Recommendation A1 from the SWAP study).[76] As actions are undertaken to implement the recommendations from this study, the implications cast a wide net over the policy status quo.

The impacts on software engineering in the DoD promulgated by these actions reflect an growing acknowledgment of the significance and prominence of software throughout the Department.

The DoD Enterprise DevSecOps Initiative, a joint program with the OUSD (A&S), DoD CIO, DISA and the Military Services, established teams (i.e., CloudOne, PlatformOne by LevelUp) focused on deploying hardened software factories for both existing and new environments within days instead of years. These initiatives pulled together top talent from across the DoD tasked with enabling the infrastructure and associated tools needed by modern software engineers to rapidly deliver software capability for the warfighter.

Software Engineering organizations across the services continue to focus on growing the workforce. Notably the Software Engineering Groups of the Air Force Sustainment Center grew the organic workforce by 8% in 2019, to a total workforce of 4500+ software engineers and computer scientists supporting over 250 distinct software projects.

Sector Outlook

The demand for rapid, responsive software update deployments is quickly moving from a desire to an expectation. From the perspective of the warfighter, adaptation at the speed of relevance is a matter of necessity to stay ahead of the ever-increasing pace of deployment practiced by our near-peer adversaries. Current DOD policies pertaining to software engineering are mired in bureaucratic obstacles that lie in opposition to the adaption of continuous integration and deployment methodologies. As the software engineering profession embraces cloud-based development environments with increasingly automated pipelines (enabling vastly shorter delivery cycles), policies must be updated to reflect this paradigm shift.

Along with the change in technologies and methods being adapted by the software engineering community, comes a requirement for a workforce with the necessary talents to effectively employ these enablers. The production of engineers and scientists with U.S. citizenship, and the skills necessary to successfully develop and sustain the software required by the DoD in modern environments, is not keeping up with demand. As of 2017, American students make up barely 21% of the computer science student body and 19% of electrical engineering majors among our Nation's universities.[77] Emphasis must be directed toward inspiring the next generation to pursue STEM careers, especially in the field of software engineering.

This issue directly threatens U.S. national self-determination in commerce and geopolitics. The STEM shortage in the DIB is quickly approaching crisis status. As stated by Arthur Herman, "We are fast approaching another Sputnik moment, we can't afford to ignore."[87] The U.S. must create a state-of-the-art STEM education strategy to cope with the reality that is upon us.

WORKFORCE SECTOR

Sector Overview

According to the North American Industry Classification System,

> *The Manufacturing sector comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products. Establishments in the Manufacturing sector are often described as plants, factories, or mills and characteristically use power-driven machines and materials-handling equipment. However, establishments that transform materials or substances into new products by hand or in the worker's home and those engaged in selling to the general public products made on the same premises from which they are sold, such as bakeries, candy stores, and custom tailors, may also be included in this sector. Manufacturing establishments may process materials or may contract with other establishments to process their materials for them. Both types of establishments are included in manufacturing.*[79]

Chart 25 shows seasonally adjusted total manufacturing employment since 2009. Approximately 2.5 million of the 12.9 million manufacturing workers work in the defense supply chain.

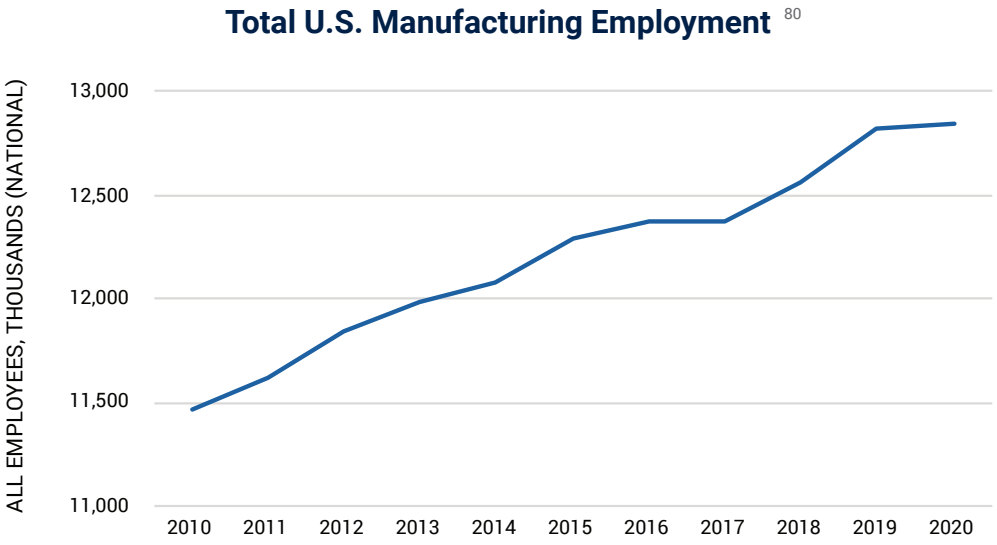


Chart 25: Source: U.S. Bureau of Labor and Statistics

Major Risks & Issues

The health of today's U.S. defense industrial base workforce—particularly in the skilled manufacturing trades—is plagued by several factors:

- A multi-decade decline in U.S. industrial/ production capacity as a share of GDP
- A loss of national focus on manufacturing and industrial skills
- A growing disconnect between the technological needs of modern manufacturing and the supply of informed, motivated, and trained workers

The U.S. finds itself in a new era of great power competition that could potentially drive large surge and sustainment defense production needs. Yet, unlike in World War II, the U.S. industrial base and its workforce must meet new and more technically complex industrial output requirements, at greater response speeds, and amidst increasingly globalized and competitive supply chains— within which our adversaries are applying subversive economic tradecraft. A 2018 Deloitte study found that most manufacturers believe that the number one cause of the skills shortage is a "shifting skill set due to the introduction of new advanced technology and automation," followed by "negative perception of students/their parents toward the manufacturing industry."[81] Retirement of many members of the Baby Boomer generation complete the top three causes of today's skills shortages, according to manufacturing executives.

Compounding the issue, DoD and many of its suppliers find themselves enmeshed in fierce domestic competition for industrial talent. The interagency task force study responding to Presidential EO 13806 reported significant workforce problems across every defense manufacturing sector. Over the next decade, studies project that nearly 3.5 million U.S. manufacturing jobs will need to be filled, and skills gaps will result in over two million of those jobs going unfilled.[82]

The manufacturing sector is in a state of transition characterized by increasing automation that seeks to enhance productivity, resilience, and agility. The Deloitte study reported that half of U.S. manufacturers said they have already adopted technologies such as robots, collaborative robots (cobots), machine learning, and artificial intelligence (AI) enabled by networks of sensors emplaced on production machines. Collectively, these advanced manufacturing technologies are referred to as "Industry 4.0." They are gradually replacing mass-production (Industry 2.0) and basic automation (Industry 3.0) manufacturing technologies, but progress is uneven, as many smaller manufacturing

firms lack the skills and/or financial resources required to implement them.

While the nation and the DoD understand the strategic implications of workforce problems, programmatic responses to-date have largely focused on STEM efforts and engineering pipelines. STEM efforts are important to the Nation's success, but the greater mass of current and projected industrial workforce shortfalls is in skilled trades. Furthermore, hiring and sustaining trade skill workers requires significant effort and time, in contrast to many service sector jobs, and impacts supply chains crossing state lines and industries. Lack of coordination on the part of public and private entities to meet workforce requirements has led to one-off and less-than-optimal national/enterprise solutions to skills shortage issues.

Nationwide workforce issues are amplified within the U.S. defense manufacturing sector. Defense manufacturers are required to produce highly complex products and systems, often on unforgiving timelines and in challenging quantities, product mixes, and scales. The availability of highly skilled trade workers and associated production capacities to meet these requirements is further undermined by uneven and disruptive product/system acquisition and funding cycles. Lastly, the economic tradecraft and other practices of competitor nations contribute to continued offshoring of U.S. labor/production capacity, as well as disincentives to sustain domestic educational and training pipelines for highly skilled manufacturing workers. Collectively, these factors account for significant degradation of U.S. defense production capabilities.

Major Developments in FY2019

In FY2019, DoD took an active role in partnering with other government agencies and multiple stakeholders to mitigate these risks. Key efforts are executed by USD(A&S)'s IBAS program and USD(R&E)'s STEM and ManTech programs.

Service-Level Efforts

Support for the Nation's manufacturing sector is not limited to the Office of the Secretary of Defense; each Military Service has its own programs focused on industrial health and manufacturing technologies. Appendix D further details relevant Service programs, extracted from the October *2019 Progress Report on the Federal Implementation of the STEM Education Strategic Plan*.

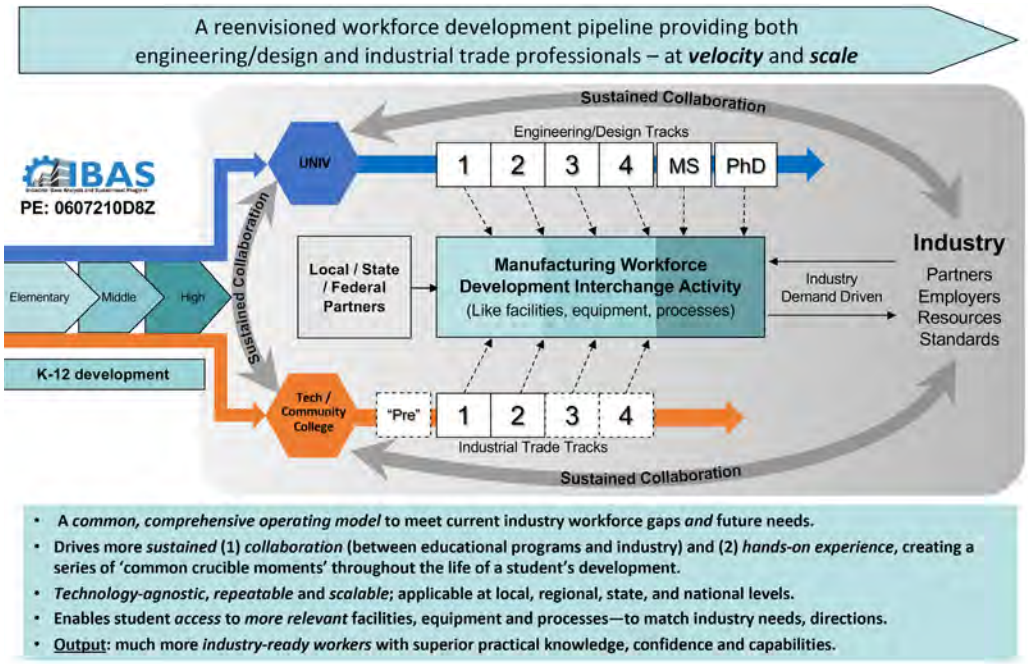
A&S Initiatives

National Imperative for Industrial Skills: IBAS began the development of a major initiative entitled the "National Imperative for Industrial Skills." The initiative's objective is to rapidly catalyze an effective national response to: a) close existing industrial workforce skill gaps, with a particular (but not sole) focus on skilled manufacturing trades, and b) leverage these gap-closing efforts to help create the conditions for sustained, multi-sector growth of national production capacities and improved industrial resiliency. This initiative is based on the twin premises that 1) the U.S. defense and national industrial bases are inextricably linked to one another, and 2) the health, capacity, and resiliency of the U.S. industrial base can be most immediately, effectively and fundamentally improved by focusing directly on closing industrial skills gaps. The operational goals of the initiative are to:

- *Promote prestige* of manufacturing and related careers and inspire the next generation of industrial skills professionals;
- *Accelerate* workers into and through training/development pipelines, at appropriate scale and velocity; and
- *Elevate* U.S. manufacturing to the world-leading status it once held.

The interagency task force study responding to EO 13806 reported significant workforce problems affecting every defense manufacturing sector. Specific workforce skill shortages affecting the DoD include, but are not limited to (in alphabetical order): additive manufacturing; composites specialties; CNC machining (metals, composites and optical materials); digital manufacturing skills and process knowledge

Figure 6: Industrial Skills Workforce Development Ecosystem Model



(e.g., use of CAD/CAM, digital ERP and PLM systems, including production planning/operations/work instruction systems, production/machine controls and cybersecurity for industrial control systems, etc.) and other Industry 4.0 applications; metrology; microelectronics; precision optics; quality assurance / quality control (including non-destructive testing); shipbuilding skills (ship and pipe fitting, metal forming, specialty welding, etc.); and welding / joining, especially for specialty materials.

Experience has shown that localized or uncoordinated, one-off approaches and attempts to close national industrial skills gaps have not and will not meet the strategic needs of the DoD and the nation, at the velocity and scale needed. Fortunately, the DoD—the largest acquirer of manufactured products and systems in the federal government—is well positioned to function as a catalyst for a coordinated effort to close workforce gaps and expand national production capacity and resiliency across the nation's industrial ecosystem.

Industrial Skills Workforce Development Ecosystem Model: The IBAS program office developed the "Industrial Skills Workforce Development Ecosystem Model" (see Figure 6) to provide a common operating model for workforce development initiatives and guide an integrated, multi-level approach. The model represents a common touchpoint for stakeholders to enable more robust dialogue, convergence of thought, and increased unity of effort across a broad spectrum of local, state, regional, and national industrial workforce development activity. The model recognizes that a number of factors must contribute to the creation of a more powerful national industrial educational system-of-systems:

- Education must reduce focus on stepwise activities in favor of improving integration between traditional 2-year and 4-year educational tracks and robust interconnection with industry;
- Industry and education must leverage digital technologies to create and leverage transferable knowledge and intelligence 'modules' throughout students' development and workers' careers. These modules will enable development of innovative curricula and credentialing programs, and new apprenticeship and internship programs targeted to strategic industrial needs;
- The financial industry and government must develop new forms of capital investment in educational and training infrastructure, and manufacturing production infrastructure and equipment;

- Tailored solutions for localized workforce pipeline needs must be integrated within a more powerful national industrial educational strategy that supports educational pipeline capacity growth and labor supply elasticity. In order to be most effective, these efforts should yield self-sustaining and/or long-term benefits.

As a first step in the implementation of the model, IBAS launched "ProjectMFG" (currently funded through FY2020), a series of DoD-sponsored state, regional, and national industrial skills challenge competitions amongst educational teams. ProjectMFG competitions are supported by public-private partnerships (consisting of companies, academic institutions, and government organizations), and focus on critical skills (advanced CNC machining, welding/joining, metrology, project management and selected Industry 4.0 skills using leading-edge digital methods) that are often difficult to fill across defense and national industrial supply chains. The competitions are intended to generate interest in manufacturing and industrial skills and associated careers.

The competitions also generate new insights and help illuminate critical shortfalls/risks and needs related to manufacturing workforce development processes; curricula/credentialing development (including apprenticeships and internships); and industrial equipment and other infrastructure build-out requirements. The first three early prototype competitions (AL, MS, LA) produced strong results and positive momentum. One also helped a participating state to identify approximately 1,000 open/unfilled machinist positions and found that it had no 5-axis CNC training programs or equipment.

R&E Initiatives

STEM Program Manufacturing Engineering Education Program Grants: In April 2019, R&E's Manufacturing Engineering Education Program (MEEP) conducted its second competition for grants. The purpose of MEEP is to establish programs to better position the current and next-generation manufacturing workforce to produce military systems and components that assure technological superiority for the DoD.

The 2019 MEEP Funding Opportunity Announcement (FOA) supported manufacturing-focused, engineering training at United States institutions including academia, industry, nonprofit organizations, and consortia of such institutions or industry. The FOA requested that respondents develop and enhance curricula and programs to: 1) effectively develop skills sets needed for students to operate in multidisciplinary design and manufacturing environments, including those for which manufacturing diagrams are driven by computational tools for modeling and simulation; and 2) prepare students to work effectively in environments where multiple engineering disciplines are engaged during design, development, and manufacturing.

Targeted subject areas include welding; manufacturing-related programming CNC, Computer Aided Design (CAD), Programmable Logic Controllers (PLC) logic, robotic control, etc.; operation and maintenance of state-of-the-art manufacturing equipment/tooling; process monitoring and optimization, and in-line quality assurance; and management of manufacturing, supply chains, and distribution. The program office selected nine of the 90 proposals submitted (see Appendix D). Each grant (total of $42 million) supports the Strategic Plan's three educational pathways.

ManTech Program Manufacturing Institutes Initiatives: The ManTech Program office has a robust portfolio of small-scale innovation programs that will be scaled to address the skills gap once the approaches are validated through prototyping pilots. In its role as lead for the eight DoD sponsored members of Manufacturing USA institutes, collectively referred to as the Manufacturing Innovation Institutes (MII), ManTech has provided ongoing support to the MIIs in the eight 2019 workforce and education development efforts (see Appendix D).

ManTech Program SBIR Initiatives: The ManTech program has taken the lead in multiple programs to develop networks and tools to address the skills gap. These include three Small Business Innovative Research (SBIR) projects (see Appendix D) and two efforts to build national-to-regional networks linking manufacturers to educational providers and resources.

Sector Outlook

In FY2020, IBAS plans to oversee up to eight more ProjectMFG state-level competitions, up to four regional competitions, and a national capstone competition at the International Manufacturing Technology Show (IMTS) in Chicago. IBAS will also formally launch the National Imperative for Industrial Skills initiative, with formal solicitations beginning in FY2020. This multi-year, multi-project initiative will be executed through other transaction agreement (OTA)-based prototyping projects competed and released through the "Cornerstone" OTA membership consortium.

This IBAS-managed portfolio of OTA projects will test and refine various aspects of the industrial skills workforce development ecosystem model, leading to higher levels of maturity and effectiveness across the industrial skills workforce development ecosystem. The National Imperative for Industrial Skills initiative will serve to close workforce gaps, and the establishment of more robust and elastic industrial workforce pipelines will invite new investment in domestic industrial capability and capacity. Expanded workforce capacity and capability will also support commercial needs and help ensure unmatched U.S. technological dominance underpinning both economic and national security.

R&E programs are approaching the public perception of manufacturing careers and the impact of primary education as social issues. Solutions must address issues across the basic human developmental lifecycle—a complex endeavor requiring multiple, cross-disciplinary approaches. This challenge is not unique to the manufacturing sector. Similar challenges are present among other technology jobs where workers must develop the necessary hybrid, soft, and digital skills through nontraditional education paths.

These workers have been referred to as "New-Collar," which includes cloud computing technicians, database managers, cybersecurity specialists, user interface designers, and individuals in other IT roles. New-Collar also characterizes a new class of technology-infused manufacturing technician job roles in areas such as additive manufacturing, robotics and automation implementation, digital twinning, simulation, and many more multidisciplinary and technically demanding roles. Education of these New-Collar workers begins when students enter school and continues well after an individual completes their formative education, necessitating widespread life-long learning.

A life-long learning process enables more responsive solutions for immediate, intermediate and long-term needs. Meeting immediate needs involves efforts enhancing the current workforce with reskilling, upskilling, and foundational skills. Solutions for intermediate-term needs can be woven into the existing curricula for those in career preparatory programs at both the advanced degree program, and at career and technical education levels. Finally, by adjusting the education model at the primary level, students can be given the foundational mental and physical skills necessary to prepare them for future careers.

The Manufacturing USA network of innovation institutes are uniquely positioned to identify the skills needed to support emerging technologies, and coordinate with educators to meet these requirements. The 14 technology-specific institutes of Manufacturing USA, bring together industry, academia, and federal partners within a growing network of advanced manufacturing stakeholders to increase U.S. manufacturing competitiveness by catalyzing the commercialization of Industry 4.0 technologies, cultivating advanced manufacturing ecosystems, and developing a skilled and capable workforce to promote a robust and sustainable manufacturing sector.

In both concept and execution, the Industrial Skills Workforce Development Ecosystem Model developed by the IBAS program and the Life-Long Learning Process model created by R&E are complementary. Efforts springing from each will be coordinated to achieve maximum impact with minimum waste. The health of the U.S. defense industrial base workforce is essential to defense readiness and U.S. national security.

CRITICAL EMERGING TECHNOLOGIES

CRITICAL EMERGING TECHNOLOGIES

Section 1793 of the FY2019 NDAA requested the Department and the Director of National Intelligence to jointly complete a review of key national security technology capability advantages, competitions, and gaps between the United States and "near peer" nations.

TMIB led the assessment for the nine technology modernization priorities identified at that time (biotechnology and 5G were added later). Each area was broken into technology sub-categories and evaluated based on five factors: technical maturity, workforce, supply chain, technical advantage, and infrastructure. The report highlighted industrial base shortfalls and opportunities but also the need to conduct deep-dive assessments in specific sub-categories.

In FY2019, TMIB concentrated its efforts on supporting industrial base assessments and initiatives related to the critical technologies identified in the 2018 National Defense Strategy. Information about each of the critical technologies is provided below.

Hypersonics

Hypersonic weapons travel five or more times the speed of sound. Currently, there is a focus on the tactical capability that these types of weapons bring to theater conflicts or regional conflicts. These weapons provide quick response and high speed, are highly maneuverable, and difficult to find, track and kill. The DoD is modernizing its offensive and defensive force structure to both utilize and deter this capability.

- TMIB is part of the Hypersonics Leadership Team assessing industry's ability to support hypersonic systems development and manufacturing. TMIB conducted a review of existing reports to provide a comprehensive view of hypersonics manufacturing and industrial base issues, risks, and opportunities. In addition, TMIB collaborated with INDPOL and the Defense Contract Management Agency to execute an industry survey to identify current risks and opportunities in this area. Currently, TMIB is developing a strategy to ensure that sufficient domestic manufacturing and industrial base capacity exists for production of hypersonic systems.

Directed Energy Weapons

When directed energy matures to a deployable capability, our armed forces will have the potential to defend against several types of threats with great precision and minimal collateral damage, at minimal cost per engagement. High Energy Laser (HEL) technology development and advancements in hardware are making laser weapon systems increasingly viable.

Artificial Intelligence (AI)/Machine Learning (ML)

The Department will leverage AI to enable U.S. forces to operate more effectively and efficiently. As a Department, we are evaluating which of our processes and procedures can be enabled via adoption of AI technology to meet warfighter needs and Defense priorities.

- TMIB is currently working on a study to identify internal data sources that could be useful for machine learning purposes.

Quantum Science

Quantum computers pose an impending threat to secure communications. Continued U.S. dominance in quantum information science will keep us ahead of these risks, and NSA crypto-modernization will protect our most sensitive communications against a quantum computer attack. Quantum sensing will deliver new and assured precision position, navigation, and timing capabilities, keeping our forces safe in GPS-denied theaters. Quantum networks will deliver drastically enhanced sensors to find and fix elusive targets and resource multiplying effects for commercially developed quantum computers to solve DoD's challenging analytical problems.

Microelectronics

Microelectronics have been rapidly evolving as the demand for inexpensive and lightweight equipment has increased and are incorporated into countless DoD systems. Our modernization ability is jeopardized by foreign microelectronics (ME) production, actions, and investments.

We must develop and deliver next generation microelectronic technologies to enhance lethality, ensure critical infrastructure, and achieve economic competitiveness.

- In April 2019 the DoD provided a report to Congress on the DoD plan to utilize FY2019 resources to accelerate the trusted microelectronics strategy and roadmap. The report also provides overviews and updates on the scope of the microelectronics problem, domestic capability and infrastructure, and testing protocols.[83]

FNC3

Fully Networked Command, Control, and Communications technology encompasses the capability to acquire, process, and disseminate information across force elements. DoD requires a clear path to robust C4I with multiple redundant fully networked communication systems. Existing capabilities require protection against growing threats, in pervasiveness and effectiveness.

- TMIB is working on a FNC3 study that will characterize the future state of relevant technology.

Space

The U.S. way of war, across all domains, is dependent on timely and assured space requirements. Adversary capabilities and advancements require us to move quickly toward a more defendable and resilient space posture. Added protection and resiliency to our current spacecraft fleet is essential.

Autonomy

Autonomy extends and complements human capabilities. Advantages include persistence, size, speed, maneuverability, and reduced risk to human life. DoD targets seamless integration of diverse unmanned/mixed team capabilities to provide flexible options for the Joint Force.

Cyber

Cyber is a unique operational domain with significant security challenges and potential leap-ahead capabilities for military operations requiring enhanced command, control, a situational awareness, and autonomous operation. Ability to gain and maintain the U.S. technological edge in cyberspace in the face of rapid evolution is essential to maintaining mission readiness.

Biotechnology

Biotechnology is any technological application that harnesses cellular and biomolecular processes. Currently, most biotech research focuses on agent detection, vaccines, and treatment. Future advances in biotechnology will improve the protection of both the general public and military personnel from adversarial biological agents, among numerous other potential applications.

5G

5G will bring about wireless, ubiquitous connectivity across humans, machines, and the Internet of Things. DoD will adapt 5G and next generation technologies to "operate through" congested and contested spectrums and in spite of compromised networks to ensure maximum readiness, lethality, and partnering among allies. 5G prototyping and experimentation will be conducted in collaboration with the defense industry and commercial suppliers to accelerate U.S. prominence in the 5G global ecosystem.

Ongoing Initiatives

In FY2020, TMIB is planning to continue emerging technology assessments, to further reduce risk, and develop and identify opportunities within the industrial base. The team will also continue to manage OUSD(R&E) CFIUS, mergers and acquisitions, and export control licenses reviews to ensure protection and promotion of critical technologies and components to support the future industrial base.

SUPPORTING AUTHORITIES & ACTIONS

DEFENSE PRIORITIES AND ALLOCATIONS SYSTEM (DPAS)

Program Objective

The purpose of the Defense Priorities and Allocations System (DPAS) is to assure the timely availability of industrial resources to meet current national defense and emergency preparedness program requirements, and to provide an operating system to support rapid industrial response in day-to-day operations and national emergencies. The Defense Production Act of 1950 authorized the President to require preferential treatment of national defense programs. DPAS establishes procedures for placement of priority ratings on contracts, defines industry's responsibilities under rated orders, and sets forth compliance procedures.

Overview

Legislative Authority:
Title I of the Defense Production Act of 1950

Oversight:
A&S INDPOL

Total DX Rated Programs: 13

Rating Determinations

All prime contracts, subcontracts, or purchase orders in support of an authorized program are given a priority rating. A DX rating is assigned to those programs of the highest national priority. Per DoD 4400.1-M, the Under Secretary of Defense for Acquisition and Sustainment (A&S) has authority to validate the request for a DX rating. If deemed necessary, the Under Secretary of Defense for Acquisition and Sustainment (A&S) will nominate the suggested program for a DX rating to the Secretary of Defense for approval.

DO Rating	DX Rating	Special Priorities Assistance (SPA)
A DO priority rating gives the DoD preference over all unrated orders Because of DoD's mission, all procurement contracts should contain a "DO" priority rating DO rated orders have equal priority among other DO rated orders, but have priority over unrated orders	Assigned to programs with the highest national defense urgency Takes preference over DO rated orders and unrated orders with the same delivery dates DOES NOT move the order in front of orders with the same rating with earlier delivery dates ONLY the Secretary or Deputy Secretary of Defense can grant a DX priority rating designation to systems or programs with the highest national defense urgency	SPAs alleviate schedule delivery conflicts during high demand periods where there are competing requirements for the same resources SPA requests should be timely for the DoD or the Department of Commerce to effect a meaningful problem resolution, and must establish that: 1. There is an urgent need for the item, and 2. The applicant has made a reasonable effort to resolve the problem

Security of Supply Arrangements (SOSA)

DPAS Ratings are only enforceable for companies subject to U.S. law. Since the U.S. defense industrial base sources from a global market, the DoD enters into SOSAs with several nations to ensure the mutual supply of defense goods and services. These bilateral arrangements allow the DoD to request priority delivery for DoD contracts, subcontracts, or orders from companies in these countries. Similarly, the arrangements allow the signatory nations to request priority delivery for their contracts and orders with U.S. firms. To date, the DoD holds nine SOSAs with U.S. allies and partners.

SOSA Countries

- Australia
- Canada
- Finland
- Italy
- The Netherlands
- Norway
- Spain
- Sweden
- United Kingdom

FY2019 Overview

FY2019 Accomplishments

In 2018, the DPAS program underwent a significant revamp with the stand-up of the Enterprise Board (EB). The EB structure provides a more responsive process to address national security requirements, including an enterprise-level approach to evaluate DX ratings, and assigning resources to mitigate competing cross-service requirements. The EB consists of the DPAS leads from OSD, the Services, Commerce, the Joint Staff, DLA, DCMA (see figure below). In 2019, one of the highlights of the role of the EB was educating the services, DoD field agencies, and industry on scope and proper usage of the DPAS system. This educational outreach has been particularly beneficial in the areas of hypersonics and the nuclear enterprise as rapidly ramping up the industrial base for these applications is a top priority for the department.

Another DPAS highlight of 2019 was that multiple delivery date conflicts were resolved amicably between the DoD and our suppliers through communication, understanding, and compromise rather than through the use of the formal Special Priorities Assistance (SPA) system. Avoiding the SPA process, when possible, reduces both overhead burden on industry as well as the Government. This outreach directly lead to the resolution of "aircraft on ground" issues impacting both DoD and our partners and allies readiness.

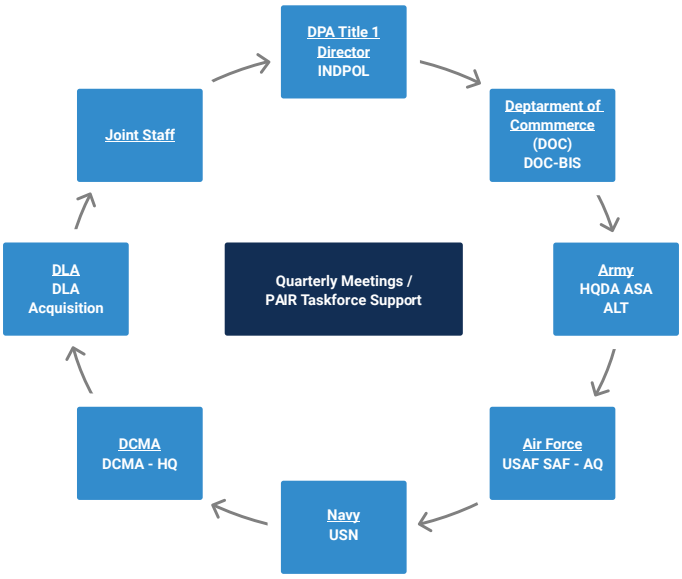


Figure. *The DPAS EB was stood up in 2018 to enhance communication and effectiveness on resolving priority issues impacting the Department.*

2020 Goals

A top 2020 priority for DPAS is to continue to educate the services and DoD agencies on DPAS authorities including the differences and applicability of DO, DX, and SPA. The Department strives to minimize the usage of DX ratings and SPAs because they can be disruptive to the commercial and Defense Industrial Base. Additionally, overuse of DX ratings may dilute the strength and effectiveness of the priority and therefore negatively impact the ability of the Department to surge in the event of a National Emergency. If everything is a priority then nothing is a priority. Additional goals for 2020 include updating the DPAS Instruction, Manual, and Continuing Operations Plan.

DEFENSE PRODUCTION ACT (DPA) TITLE III

Program Objective

The Defense Production Act (DPA) Title III program manages the Department's responsibilities for executing authorities under Title III of the DPA of 1950. Title III of the DPA provides the President broad authority to ensure timely availability of domestic industrial resources essential for the execution of the national security strategy of the United States through the use of tailored economic incentives, including:

- Purchases/Purchase commitments (Sec 303(a))
- Development of production capabilities and increased use of emerging technologies (Sec 303(a))
- Loans/Loan guarantees (Sec 301 & 302)[1]
- Installation of Production Equipment in Government or Privately-Owned Facilities (Sec 303(e))

Specifically, the program is designed to create, maintain, protect, expand, or restore domestic industrial base capabilities essential to U.S. national defense. Title III authorities are utilized when the President determines that essential domestic industrial base capabilities do not exist, are at risk of loss, or are insufficient to meet government needs. Title III incentives stimulate private sector investment in essential capabilities by reducing the risks associated with the required capitalization and investment to establish the required productive capacity.

Overview

Legislative Authority:
Title III of the Defense Production Act of 1950

Established: 1950, reauthorized in 2018

Oversight: A&S INDPOL

FY2019 Budget: $38.6M

Presidential Determinations

Absent exceptional circumstances such as a period of national emergency, the President must issue a determination and notify Congress prior to the utilization of Title III authorities to address a domestic industrial base shortfall. The Presidential Determination must that:

- The industrial resource, material, or technology item is essential to the national defense;
- Without Presidential action, industry cannot reasonably be expected to provide the capability in a timely manner;
- DPA Title III incentives are the most cost-effective, expedient, and practical alternative method for meeting the need.

1. The Defense Production Act of 1950, as Amended [50 U.S.C. App. § 2061 et seq.] Title III - Expansion of Productive Capacity and Supply, https://www.fema.gov/media-library-data/20130726-1650-20490-7493/the_defense_production_act_title_iii__december_2008_.pdf
2. See Appendix D for detailed information about DPA Title III projects.
3. DPA Title III program website, https://www.businessdefense.gov/Programs/DPA-Title-III/

Investment Areas

DPA Title III projects address three broad priority areas, as defined in section 303(a) of the Defense Production Act:

Sustain Critical Protection	Commercialize R&D Investments	Scale Emerging Technologies
"To create, maintain, protect, expand, or restore domestic industrial base capabilities essential for the national defense."	"From Government sponsored research and development to commercial applications;" and "from commercial research and development to national defense."	"For the increased use of emerging technologies in security program applications and the rapid transition of emerging technologies."

FY2019 Signed Presidential Determinations:

- Alane Fuel Production
- Circular Lithium-Seawater Batteries Production
- Critical Chemicals for DoD Missiles and Munitions – Precursors
- Critical Chemicals for DoD Missiles and Munitions – Inerts
- Critical Chemicals for DoD Missiles and Munitions – Energetics
- Critical Chemicals for DoD Missiles and Munitions – Advanced Manufacturing Techniques
- Sonobuoys Production
- Small Unmanned Aerial Systems
- Light Rare Earth Elements Separation and Processing
- Heavy Rare Earth Elements Separation and Processing
- Rare Earth Element Metal and Alloy Production
- Neodymium Iron Boron Rare Earth Permanent Magnet Production
- Samarium Cobalt Rare Earth Permanent Magnet Production
- Integrally Bladed Rotors Production

FY2019 Overview:

- At end of FY 2019, DPA Title III portfolio of 37 projects leveraging $1+B in government and industry funding to increase the lethality and readiness of the nation by strengthening the domestic industrial base
- In support of Executive Order 13806, President issued 14 Presidential Determinations addressing critical areas such as the rare earths supply chain and chemical production
- New projects in FY 2019 strengthening the domestic industrial base in key sectors including microelectronics, strategic materials, homeland security, and advanced materials[2]
- New Hybrid Funding Opportunity Announcement contracting vehicle launched in July to streamline acquisition process and compress timeline[3]

Website: https://www.businessdefense.gov/Programs/DPA-Title-III/

COMMITTEE ON FOREIGN INVESTMENT IN THE UNITED STATES (CFIUS)

Program Objective

CFIUS is an interagency committee that reviews certain foreign acquisitions, mergers, or takeovers of U.S. businesses to determine the effect of a transaction on the national security of the United States. The Committee is chaired by the Secretary of the Treasury and includes nine voting members and seven non-voting participants. Under the authority, direction, and control of the Under Secretary of Defense for Acquisition and Sustainment (USD(A&S)) Industrial Policy (IndPol) manages the CFIUS process for the Department.

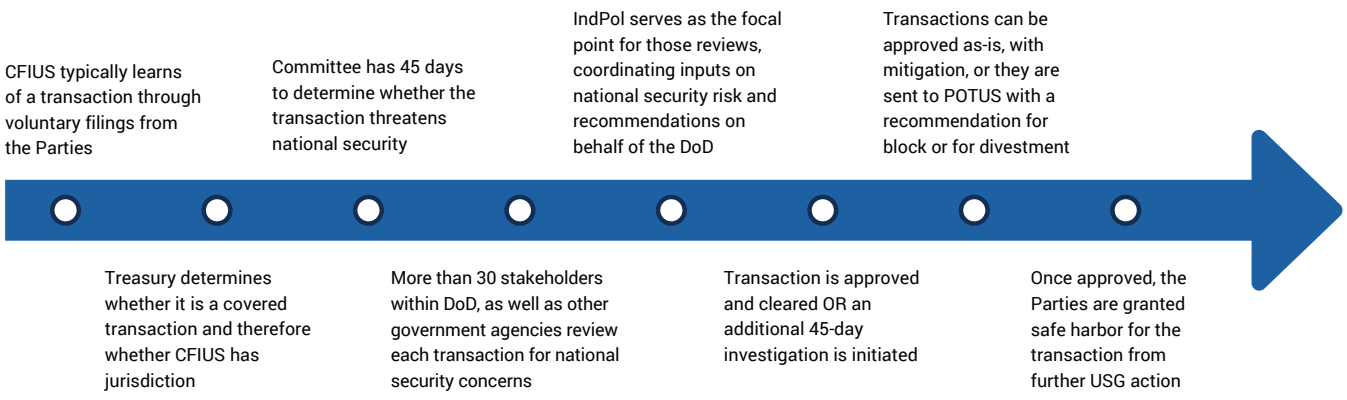
Overview

Legislative Authority:
§ 721 of the Defense Production Act of 1950

Established: 1988

Oversight:
Global Markets and Investments (GMI), A&S INDPOL

Review Process



CFIUS Legislative History:

- **1975** The basic structure of CFIUS was established by Executive Order
- **1988** "Exon-Florio" amendment defined the CFIUS review process over foreign investments
- **1992** "Byrd Amendment" expanded CFIUS reviews to include cases in which foreign acquirer was acting on behalf of a foreign government.
- **2007** Foreign Investment and National Security Act (FINSA) replaced the 1975 Executive Order and codified CFIUS fiving it statutory authority
- **2018** Foreign Investment Risk Review Modernization Act (FIRRMA) expanded the jurisdiction of CFIUS and allows CFIUS to discriminate among foreign investors by country of origin

FY2019 Overview:

On August 13, 2018, Congress signed into law the Foreign Investment Risk Review Modernization Act of 2018 (FIRRMA). FIRRMA expands the jurisdiction of CFIUS by adding four new covered transactions:

1. a purchase, lease, or concession by or to a foreign person of real estate located in proximity to sensitive government facilities
2. other investments" in certain U.S. businesses that afford a foreign person access to material nonpublic technical information in the possession of the U.S. business, membership on the board of directors, or other decision-making rights, other than through voting of shares
3. any change in a foreign investor's rights resulting in foreign control of a U.S. business or an "other investment" in certain U.S. businesses
4. any other transaction, transfer, agreement, or arrangement designed to circumvent CFIUS jurisdiction

Additionally, FIRRMA establishes a "light filing" process for transaction disclosures traditionally outside of the scope of CFIUS; extends the CFIUS review period; strengthens requirements on the use of mitigation agreements; and grants special hiring authority for CFIUS and establishes a fund for collection of new CFIUS filing fees.

Website: https://www.businessdefense.gov/Programs/Global-Markets-and-Investments/

OFFICE OF SMALL BUSINESS PROGRAMS (OSBP)

"A strong, dynamic, and robust small business sector is critical to the health of our economy. Small businesses buttress production of the most cutting-edge technologies and advanced capabilities, bolster our national security, and form an important part of our industrial base. The DoD recognizes that small businesses are a crucial component in our nation's effort to meet increased challenges from competitors and adversaries that threaten U.S. technological and industrial dominance"

– Small Business Strategy (October 2019)

Program Objective

The Office of Small Business Programs (OSBP) maximizes prime and subcontracting opportunities for small business to respond to current and future Warfighter requirements. This results in an innovative, cost effective, and agile industrial base, to directly support the National Defense Strategy and a robust economy.

The complexity of DoD requirements and contracting processes can preclude new entrants to the defense market. This is particularly true of small businesses that do not have the manpower and resources necessary to navigate and compete for defense contracts. The following programs help bring new business into the defense industrial base by creating a pathway for non-traditional contractors to participate and succeed.

DoD Mentor-Protégé Program:

The MPP helps eligible small businesses expand their footprint in the defense industrial base and becoming reliable government contractors. This expansion of capable small businesses makes the defense industrial base more reliable and sustainable.

Overview

Oversight:
A&S INDPOL

DoD Mentor Protégé Program (MPP):
Established: 1990
Authority: §831 of the FY1991 NDAA

Indian Incentive Program (IIP)
Established: 1997
Authority: 25 USC Section 1544

As a result, mentors, typically large defense contractors, can leverage the nimble and agile nature of small businesses and their technologies, services, and cutting-edge products to improve the innovation in major defense acquisition programs.

Indian Incentive Program:

The IIP is a congressionally sponsored program that provides a five percent rebate to a prime contractor on the total amount subcontracted to an Indian-Owned Economic Enterprise or Indian Organization in accordance with DFARS Clause 252.226-7001. Through the generation of subcontracts, the IIP serves as an economic multiplier for Native American communities. DoD prime contractors with a subcontract worth $500,000 or more that contains the DFARS clause are eligible for incentive payments. Since FY2015, the IIP has funded more than 570 rebates totaling $85M in incentive payments, which leveraged $1.7B in subcontract performance by Native-owned firms.

FY2019 Overview

CYBERSECURITY

In FY2019, OSBP offered trainings across the country to help small businesses comply with DFARS regulations on cybersecurity readiness. Over 7,000 small businesses were trained and more than 30 cybersecurity tools were evaluated. Additionally, OSBP partnered with US Cyber Command to launch Project Spectrum to enhance awareness of cybersecurity threats among small manufacturers and universities working on DoD programs and activities through training, conducting risk assessments and rapid prototyping of new technologies.

DOD SMALL BUSINESS STRATEGY

OSBP submitted the DoD Small Business Strategy to Congress in October of 2019. The strategy focuses on three strategic objectives:

SMALL BUSINESS TRAINING WEEK

OSBP successfully hosted the largest-ever training week for small business professionals. The 800 attendees represented Procurement/SB Professionals (398); Program Directors/Deputies (155); Contracting Specialists/Officers (192); and Program Managers (55).

The training week theme was "Change," emphasizing the Department's direction to better align the small business industrial base to the Department's mission and the capability gaps and industrial base challenges identified in the Executive Order 13806 report. Attendees were challenged to embrace change with a renewed 'patriotic passion to serve small businesses that protect our warfighter.'

2020 Goals

In 2020, the DoD Office of Small Business Programs hopes to expand its role in supporting the industrial base by integrating small business into the various offices and programs within Industrial Policy. Specifically, small business is eager to support areas concerning Microelectronics, Trusted Capital, Assessments, Rare Earth Minerals, Hypersonics, etc. OSBP welcomes collaboration in tackling critical issues facing the industrial base. Small businesses are the backbone of our economy and offer the innovation and readiness needed to support the Department's mission.

Furthermore, OSBP plans to roll out the Small Business Placemat in 2020. The placemat will be a tool designed to help small businesses do business with the government. Phase I of the placemat's rollout was finished in late 2019, while Phases II and III are expected to be finalized in the coming months. Once it is officially implemented in 2020, OSBP will serve as a helpdesk for small business users and assist with the process.

Website: https://business.defense.gov/

INDUSTRIAL BASE ANALYSIS AND SUSTAINMENT (IBAS)

Program Objective

The IBAS Program seeks to strengthen the posture of the US Defense Industrial Base (DIB) in the era of great powers and global competition. The program's ultimate objective is to create a modern Industrial Base that fortifies traditional and forges emerging sectors to respond at will to National Security Requirements. IBAS investments improve industrial base resilience to improve force readiness.

IBAS Program Priorities:

- Ready the Modern DIB - Advance and sustain traditional defense mfg. sectors
- Prepare for the Future - Identify, attract, and cultivate emerging defense sectors
- Assess and Shape the Risk - mitigate supply chain vulnerabilities within the Global DIB
- Build and Strengthen - Partnerships in the Global DIB

Investment Strategy

The IBAS office directs investment by identifying strategy/focus areas, obtaining resources, and overseeing execution of projects, aiming to ameliorate industrial base and manufacturing issues and strengthen the defense industrial base. All projects are evaluated for industrial base risk using a framework of risk assessment methodologies and tools, such as fragility and criticality risk criteria, to develop feasible and effective course of actions. Key areas of IBAS investment include:

- Advancing and sustaining both traditional and emerging defense manufacturing sectors
- Preserving critical and unique manufacturing and design skills
- Supporting and expanding reliable sources
- Identifying and mitigating supply chain vulnerabilities, including cyber, manufacturing, and trade skills vulnerabilities

Overview

Legislative Authority:
10 U.S. Code § 2508. Industrial Base Fund

Established: FY2014

Oversight: A&S INDPOL

FY2019 Budget: Core: $48.8M
Cong. Adds: $38.5

Cornerstone

The Cornerstone Other Transaction Authority (OTA) is a government-run, integrated contract vehicle used to create dynamic relationships across the defense industrial base using the IBAS authorities. The Cornerstone OTA authority originates from 10 U.S. Code 2371b - Authority of the DoD to carry out prototype projects. Cornerstone focuses on "prototype" projects, capabilities, and capacities in support of a range of defense industrial base requirements across 18 sectors.

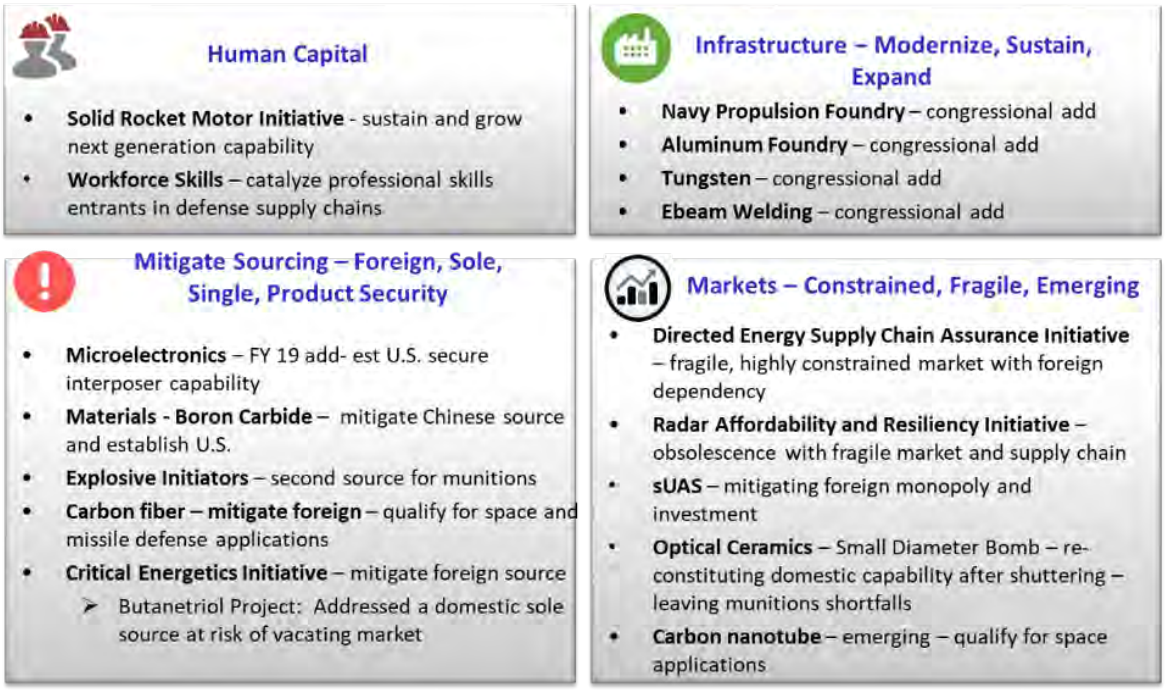
Cornerstone Sector and Requirements Focus Areas

- Aircraft
- Radar & Electronic Warfare
- Shipbuilding
- Ground Vehicles
- Soldier Systems
- Space
- Chemical, Biological, Radiological, & Nuclear (CBRN)
- Materials
- Machine Tools
- Cybersecurity for the Industrial Base
- Optics
- Advanced Technology & Advanced Manufacturing
- Electronics
- Command, Control, Communications, & Computers (C4)
- Munitions & Missiles
- Industrial Base & Manufacturing Skills
- Trusted Capital
- Special Operations Forces (SOF) Operational Requirements

FY2019 Overiew

In FY2019, IBAS continued to address issues identified in EO 13806 finding and ABS priortity programs - partnering on investments and areas of shared interest. IBAS aims to catalyze investments in critical ares where momentum is absent.

FY2019 Investments



Website: https://www.businessdefense.gov/IBAS/

SMALL BUSINESS INNOVATION RESEARCH
SMALL BUSINESS TECHNOLOGY TRANSFER

Program Objective

The statutory purpose of the SBIR program is to strengthen the role of innovative SBCs in Federally-funded research or research and development (R/R&D), in order to:

- Stimulate technological innovation
- Involve small business to meet Federal R/R&D needs
- Foster and encourage participation by socially and economically disadvantaged SBCs (SDBs), and by women-owned SBCs (WOSBs), in technological innovation;
- Increase private sector commercialization of innovations derived from Federal R/R&D, thereby increasing competition, productivity and economic growth.

In addition to the broad goals of the SBIR program, the statutory purpose of the STTR program is to stimulate a partnership of ideas and technologies between innovative SBCs and non-profit Research Institutions. By providing awards to SBCs for cooperative R/R&D efforts with Research Institutions, the STTR program assists the U.S. small business and research communities by supporting the commercialization of innovative technologies.

Small Business Innovation Research (SBIR) Program:

SBIR encourages domestic small businesses to engage in Federal R/R&D on initiatives that have the potential for commercialization. Through a competitive awards-based program, SBIR enables small businesses to explore their technological potential and provides the incentive to profit from commercialization; stimulates high-tech innovation from non-traditional contractors; and encourages entrepreneurial spirit as the Federal agencies meets its specific research and development needs. As required by statute, each Federal agency with an extramural budget for R/R&D in excess of $100,000,000 must participate in the SBIR Program and reserve a minimum percentage of its R/R&D budgets for small business R/R&D contracts.

Overview

Legislative Authorities:
15 USC Section 638

Established: 1982/1992

Oversight: USD (R&E) Small Business & Technology Partnerships

Small Business Technology Transfer (STTR) Program:

STTR expands funding opportunities in the federal innovation R&D arena. Central to the program is expansion of public/private sector partnerships to include joint venture opportunities for small businesses and non-profit research institutions. Unique to the STTR program is the requirement for the small business to formally collaborate with a research institution in Phase I and Phase II. STTR's most important role is to bridge the gap between basic R&D and commercialization of resulting innovations. As required by statute, each Federal agency with an extramural budget for R/R&D in excess of $1,000,000,000 must participate in the SBIR Program and reserve a minimum percentage of its R/R&D budgets for small business R/R&D contracts.

The SBIR/STTR Programs are structured in three phases:

Phase I: Project Feasibility— determines the scientific, technical and commercial merit and feasibility of proposals.

Phase II: Project development to prototype (the major research and development effort)— funding the prototyping and demonstration of the most promising Phase I projects.

Phase III: Commercialization (the ultimate goal of each SBIR/STTR effort)—Phase III work must be funded by sources outside the SBIR/STTR Program.

Eligibility: To receive SBIR/STTR funds, each Phase I or Phase II selectee must qualify as an SBC at the time of award and must submit a certification stating that it meets the size, ownership and other requirements of the SBIR/STTR Programs at the time of award, and at any other time set forth in SBA's regulations. Additionally, the Phase I and Phase II work must be performed in the United States.

FY2019 Overview

Economic Impact Study October 2019

- The Study was conducted by TechLink, a national DoD partnership intermediary (PIA) at Montana State University-Bozeman, in collaboration with the University of Colorado in Boulder. The results quantify the DoD SBIR/STTR Programs' overall contribution to the nation's economy and defense mission through an evaluation of economic outcomes and impacts from DoD SBIR/STTR Phase II contracts initiated during the 1995-2012 fiscal years. *Major findings of the study include:*

REI Systems awards SBIR Phase III for SBIR/STTR Portal

- The Phase III Portal builds on the successful SBIR funding provided to REI Systems by NASA, and captures the inputs and requirements of numerous DoD components that participated in a road mapping process. The portal will better facilitate DoD SBIR/STTR proposal intake and make data collection and reporting more efficient

FY2020 Goals

The Small Business and Technology Partnerships (SBTP) office's primary goal is to increase awareness of the SBIR and STTR Programs within the Department and encourage small innovative businesses to work with DoD to solve National Security challenges. The following objectives will help achieve this goal:

- Implement legislative changes to the SBIR/STTR programs in accordance with the FY20 NDAA.
- Engage with other DoD and Federal stakeholders on SBIR/STTR best practices.
- Participate in outreach events across the country to educate the small business community on the DoD SBIR/STTR programs.
- Enhance the Defense SBIR/STTR Innovation Portal (DSIP) based on feedback from users and stakeholders.
- Identify and establish relationships with new partners.

$121 BILLION
In total sale of new products and services

22:1 RETURN
On the DoD Investment

$28 BILLION
In sales of new products to the U.S. Military

$347 BILLION
In total economic impact nationwide

1,508,295 JOBS
with average compensation of $73.461

Website: https://www.sbir.gov/

RAPID INNOVATION FUND (RIF)

Program Objective

The Rapid Innovation Fund (RIF) Program was established by the FY 2011 National Defense Authorization Act (NDAA) as a competitive, merit-based program designed to accelerate the fielding of innovative technologies from Phase II Small Business Innovative Research / Technology Transfer (SBIR/STTR), defense laboratories and other sources into military systems.

RIF goals reflect DoD emphasis on rapid, responsive acquisition and engagement of small business innovative technologies to resolve operational challenges and address critical national security needs. These technologies include but are not limited to capabilities that:

- Accelerate or enhance a military capability;
- Reduce the development, acquisition, sustainment or lifecycle costs of defense acquisition programs or fielded systems;
- Reduce program technical risk;
- Improve the timeliness and thoroughness of test and evaluation.

RIF efforts support the pillars of the National Defense Strategy (NDS): 1) improve force readiness and lethality; 2) develop alliances; and 3) institute business reforms. In FY2019, RIF aligned requirements with NDS modernization priority areas supported by the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)).

Overview

Legislative Authority:
Public Law 116-92, Section 878

Established: 2011

Oversight: OUSD(R&E) Small Business & Technology Partnerships

RIF Selection Process

Individual projects limited to $3M each & 24-month performance period

1. **Step 1:** Issue annual BAA for WP solicitation
2. **Step 2**: Invite highest-rated WPs for full proposals
3. **Step 3:** Award highest-rated full proposals

FY2019 Major Developments

Congress appropriated $250M to RIF in FY 2019 funding. FY 2019 program highlights include:

Army, Air Force, Navy, 22 DoD Organizations participated in whitepaper (WP) solicitations

- $120M projects selected by OUSD(R&E) Modernization Assistant Directors (ADs)
- $120M mission priority projects selected by Military Services and DoD Agencies

New review board established to align project selections with modernization roadmaps

- Chaired by RIF Director and composed of OUSD(R&E) Modernization ADs

RIF broad agency announcement (BAA) participation no longer required

- Projects derived from similar competitive process or SBIR/STTR can participate directly in source selection
- Data preparation for anticipated FY 2020 NDAA RIF reporting requirement
- FY 2011-16 small business participant study commissioned from TechLink, a national DoD partnership intermediary at Montana State University-Bozeman
- RIF Office reconciliation of project data

RIF Office oversight increased from proposal through award phases

- Cradle-to-grave project tracking to link program and financial team efforts
- Monthly financial updates to decrease risk from contract issues
- Quarterly updates from OSD RIF Office to program managers (PMs)
- Quarterly performance project performance reviews with all RIF PMs

Financial process streamlined to shorten award timeline

- Funds request paperwork and process simplified
- New financial deadlines
  - Award in 90 days from funds receipt
  - Award no later than 01 Jun 202

Current Financial Impact

Total Military Sales: **$2.42B**

Total Civilan Sales: **$0.48B**

Estimated Savings: **$4.50B**

2,212 WHITEPAPERS → **151** PROPOSALS → **94** ANTICIPATED AWARDS → **$2.5M** EACH

Website: https://dodrif.us/

MANUFACTURING TECHNOLOGY (MANTECH)

Program Objective

The DoD Manufacturing Technology (ManTech) program is designed to anticipate and close gaps in manufacturing capabilities through the development and application of advanced manufacturing technologies and processes that will reduce the acquisition and supportability costs of defense weapon systems and reduce manufacturing and repair cycle times across the life cycles of such systems.

The Army, Navy, Air Force, Defense Logistics Agency (DLA), Missile Defense Agency (MDA), and OSD each operate a ManTech investment program. The directors and senior managers of these ManTech programs coordinate through the auspices of the Joint Defense Manufacturing Technology Panel (JDMTP). The JDMTP is chartered to identify and integrate requirements, conduct joint program planning, and develop joint strategies.

Priority Areas

- **OSD: Mission Focused:** FNC3, Space (Offense & Defense), Missile Defense, Cybersecurity (Offense and Defense), Nuclear Modernization

  Technology-Focused: Hypersonics (Offense and Defense), Directed Energy, Machine Learning (AI), Quantum Science, Microelectronics
- **Army:** Long Range Precision Fires, Future Vertical Lift, Soldier Lethality
- **Navy:** Metals, Composites Electronics Processing/Fabrication
- **Air Force:** Cybersecurity, Future Factory and Digital Enterprise, Hypersonic Strike
- **DLA:** Castings/Forgings, Subsistence Networks, Additive Manufacturing
- **MDA:** Sensor Technology, Directed Energy, Kinetic Weapons

Overview

Legislative Authority: Title 10, U.S. Code §2521

Established: 1956

Oversight: USD (R&E),), Office of Strategic Technology Protection and Exploitation

OSD has two manufacturing technology investment strategies for its Defense-wide Manufacturing Science & Technology (DMS&T) program: the OSD ManTech program and the DoD-led manufacturing innovation institutes. DMS&T was established to address cross-cutting, game-changing initiatives that are beyond the scope of any one Service or Defense Agency. The OSD ManTech program is aligned to USD(R&E)'s ten mission and technology focused modernization areas that play an integral role in advancing the U.S.'s path to developing advanced capabilities for the Warfighter.

Manufacturing Innovation Institutes

The OSD ManTech Program also sponsors eight manufacturing innovation institutes (MII) with headquarters and hubs across the country. Each institute is a public-private partnership designed to overcome the challenges faced by manufacturing innovators in a variety of technology areas. While each institute operates in its own unique ecosystem, the institutes offer common capabilities: providing access to state-of-the-art tools and equipment that are otherwise beyond the reach of most businesses, implementing targeted education and workforce development training programs, and encouraging

project investments in applied research &industrially-relevant manufacturing technologies.

The DoD institutes bring new technologies to U.S. warfighters through over $870M in federal investment from the DoD and over $1.6B matching funds from industry, academia, and state governments.

FY2019 OVERVIEW

MANTECH

Army: Improved Infrared Sensors for Soldier Lethality and Situational Awareness: Increased the Warfighter's lethality and situational awareness. Improves sensor yields and decreases core costs.

Air Force: Improved Process Modeling and Expert Elicitation to Reduce Variability in Hypersonic Aeroshell Coatings: Reduced re-coating processing steps that added unnecessary cycle time, Material Review Board actions, cost, and schedule uncertainty.

OSD: High Yield Focal Plane Arrays (FPAs): has improved FPA yields from ~8% to ~43% by decreasing handling operations and improving dicing processes. This will result in projected cost savings of ~20% per unit with applications in 3GEN FLIR, SM-3, and UAS domains.

Navy: (OLED Microdisplays) Simplified Manufacture of F-35 Helmet-Mounted Displays (HMD): developed and demonstrated a manufacturing process to assemble an OLED display into the existing optical train of the F-35 Lightning II HMD. This resulted in improved visibility during night operations; reduced part count by 27%; reduced assembly fixture count by 50%; reduced touch labor by 10%; and reduced life-of-program costs by $17.4M.

Defense Logistics Agency: Microcircuit Emulation: Established manufacturing capability for over 100 microcircuit NSNs that have become obsolete and that now support over 500 weapon systems. Benefits include Increased readiness and reduced total ownership cost.

MDA: Long Range Discrimination Radar (LRDR) production: Employed a "one-factory" approach to exploit site-specific expertise and manufacturing technologies spanning multiple existing factories linked by a common MRP system. Technology insertion included an RF Bullet Feed Robot to automate blind-mate processes; fully automated insertion, test and optical inspections; a standardized antenna super fixture that eliminates damage due to fixture swaps; and an automated conformal coat line to process more than 45,000 circuit cards.

America Makes: National Additive Manufacturing Innovation Institute

America Makes: National Additive Manufacturing Innovation Institute

MxD: Manufacturing times Digital

LIFT: Lightweight Innovations for Tomorrow

AIM Photonics: American Institute for Manufacturing Integrated Photonics

NextFlex: America's Flexible Hybrid Electronics Institute

AFFOA: Advanced Functional Fabrics of America

BioFabUSA: Advanced Regenerative Manufacturing Institute

ARM: Advanced Robotics for Manufacturing Operational Requirements

Website: https://defenseinnovationmarketplace.dtic.mil/business-opportunities/mantech-program/

HART-SCOTT-RODINO ACT (HSR)

Program Objective

The Hart-Scott-Rodino (HSR) Act was established to avoid some of the difficulties and expenses encountered when challenging anticompetitive mergers and acquisitions after the fact. It is often impossible to restore competition fully once a merger takes place, and any attempt to reestablish competition after the fact is usually very costly for the parties and the public.

As such, the HSR Act requires that parties to certain mergers or acquisitions notify the Federal Trade Commission (FTC) and the Department of Justice (DOJ) before consummating a proposed acquisition. Once notifying the FTC and DOJ, the parties must wait a specific period of time (generally 30 days) while these enforcement agencies review the proposed transaction. The review period enables the FTC and DOJ to determine which acquisitions are likely to be anticompetitive and to challenge them at a time when remedial action is most effective.

Overview

Establishing Statute: Hart-Scott-Rodino Antitrust Improvements Act of 1976, 15 U.S.C. 18a. 7a of the Clayton Act

Oversight: AES INDPOL

Effective: September 5, 1978

Determining Reportability

As a general matter, the HSR requires both acquiring and acquired persons to file notifications under the Program if all of the following conditions are met:

1. As a result of the transaction, the acquiring person will hold an aggregate amount of voting securities, non-corporate interests (NCI) and/or assets of the acquired person valued in excess of $200 million (as adjusted) , regardless of the sales or assets of the acquiring and 2 acquired persons
2. As a result of the transaction, the acquiring person will hold an aggregate amount of voting securities, NCI and/or assets of the acquired person valued in excess of $50 million (as adjusted) but at $200 million (as adjusted) or less
3. One person has sales or assets of at least $100 million (as adjusted)
4. The other person has sales or assets of at least $10 million (as adjusted).

CASE STUDY

In October 2018, two major defense suppliers announced their pending merger of equals with the transaction valued at $34 billion, resulting in the creation of one of the largest defense contractors by revenue. Both companies served as prime contractors and subcontractors to multiple customers within the DoD, notably the Army, Navy, Air Force, and USSOCOM. Shortly after announcing their intent to merge, the companies filed the Hart-Scott-Rodino premerger review documents. The DoD worked closely with the DOJ, the lead antitrust agency for the case, during the entirety of the review to to assess the impact on competition, as well as facilitate discussions with DoD stakeholders to examine all identified overlapping capabilities for horizontal or vertical conerns.

The review revealed that the overlap in the companies' military-grade night vision google (NVG) businesses would present a potential threat to competition within the defense industrial base as they were the only two suppliers of military-grade NVGs and image intensification (I2) tubes. As a result, one company was required to divest its NVG business. The DOJ and DOD had an opportunity to vet the potential buyers for the divested business, and in April 2019, it was announced that the American subsidiary of an Israeli defense firm entered into an agreement to purchase the divested NVG business. In June 2019, following the second request period, DoJ filed a consent decree, approving the merger on the condition that the pending divestiture be completed. The merger officially closed in June 2019.

FY2019 OVERVIEW

FY2019 HSR Actions:

In FY19, DoD assessed 27 transactions as part of the HSR premerger review process. Of those 27 transactions, 19 investigations were initiated and eight were continuing investigations or mitigation efforts from previous fiscal years.

The average value of the transactions whose financial terms were disclosed was $18.73 billion. Much of this is attributed to outlier transactions, including the pending merger between United Technologies and Raytheon, and the merger between Praxair and Linde. Those transactions were valued at $120B and $90B respectively

The large majority of the transactions investigated were in the Aerospace and Defense sector. Three transactions included companies in the Industrials sector and two transactions included companies in the Consumer Goods Sector.

Major HSR actions that had DOD exposure from FY19 include:

- United Technologies/Raytheon (pending)
- L3 Technologies/Harris
- IBM/Red Hat
- CPI/General Dynamics SATCOM Technologies (pending).

Website: https://www.businessdefense.gov/Industrial-Assessments/Mergers-and-Acquisitions/

SECTION 232 INVESTIGATION

Program Objective

The purpose of the investigation is to determine the effect of imports on the national security. Investigations may be initiated based on an application from an interested party, a request from the head of any department or agency, or may be self-initiated by the Secretary of Commerce. The Trade Expansion Act of 1962, as amended, authorizes the President of the United States, through tariffs or other means, to adjust the imports of goods or materials from other countries if it deems the quantity or circumstances surrounding those imports to threaten national.

The Secretary's report to the President, prepared within 270 days of initiation, focuses on whether the importation of the article in question is in such quantities or under such circumstances as to threaten to impair the national security. The President can concur or not with the Secretary's recommendations, and take action to "adjust the imports of an article and its derivatives" or other non-trade related actions as deemed necessary.

Overview

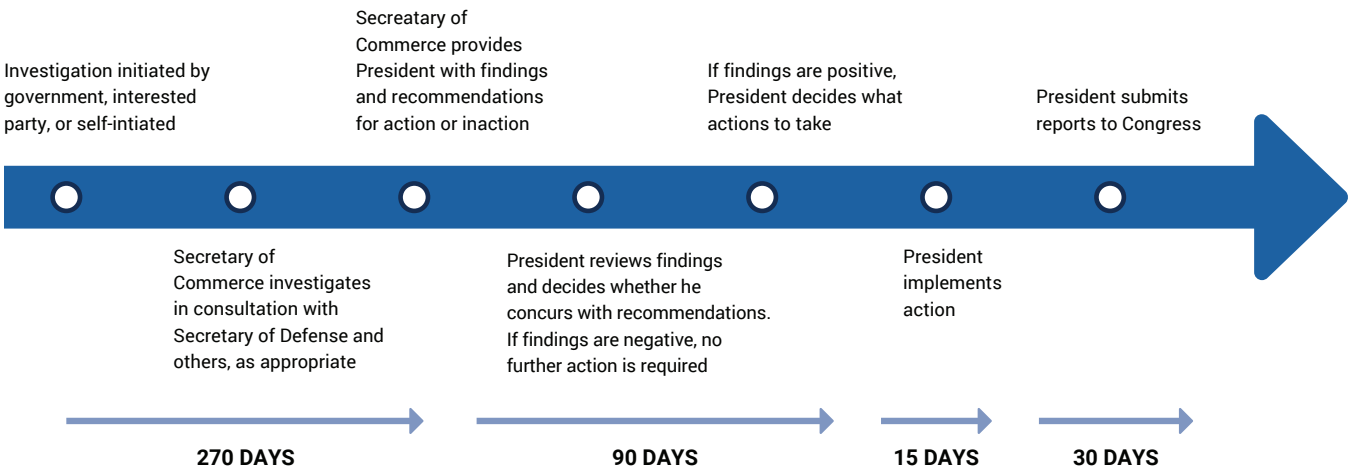
Legislative Authority: Trade Expansion Act of 1962, as amended

Oversight: Department of Commerce (DOC), Bureau of Industry and Security (BIS)

Consulted Party: A&S INDPOL, Assessments

Role Of The Department Of Defense

Section 232 requires that the Secretary notify the Secretary of Defense that an investigation has been initiated. The Secretary of Commerce also consults with the Secretary of Defense regarding methodological and policy questions raised in the investigation and can seek information and advice from other government agencies.



Section 232 Investigations 1963-2019

Potential Threat: **12**
No Potential Threat: **16**
Ongoing: **2**
Terminated: **1**

FY19 Update

Automobiles: On February 17, 2019, the Secretary of Commerce transmitted a report with the findings of the Automobile Section 232 Investigation to the President. The report found that automotive research and development (R&D) is critical to national security. The President concurred with the Secretary's finding that automobiles and certain automobile parts are being imported into the United States in such quantities and under such circumstances as to threaten to impair the national security of the United States. The President directed the United States Trade Representative (USTR) to pursue negotiation of agreements contemplated in 19 U.S.C. 1862(c)(3)(A)(i) to address the threatened impairment of the national security with respect to imported automobiles and certain automobile parts.

Uranium: On April 14, 2019, the Secretary of Commerce transmitted a report with the findings of the Uranium (uranium ore, uranium concentrate, uranium hexafluoride, enriched uranium, and enriched uranium in fuel assemblies) Section 232 Investigation to the President. The Secretary found and advised the President that uranium is being imported into the United States in such quantities and under such circumstances as to threaten to impair the national security of the United States as defined under section 232 of the Act. The President decided that an in depth analysis of national security considerations with respect to the entire nuclear fuel supply chain was necessary. The Assistant to the President for National Security Affairs and the Assistant to the President for Economic Policy established a United States Nuclear Fuel Working Group to develop recommendations for reviving and expanding domestic nuclear fuel production and present their findings to inform further actions.

Titanium: On March 2, 2019, the Secretary of Commerce formally initiated an investigation on titanium sponge notifying the Secretary of Defense. November 29, 2019, the Secretary of Commerce transmitted a report with the findings to the President.

Year	Covered Products
2018	Titanium Sponge
2018	Uranium
2018	Automobiles
2017	Steel
2017	Aluminum
2001	Iron Ore and Semi-Finished Steel
1999	Petroleum
1994	Petroleum
1992	Integrated Circuit Ceramic Packages
1991	Gears and Gearing Parts
1988	Uranium
1988	Plastic Injection Molding Machinery
1987	Petroleum
1987	Antifriction Bearing
1983	Metal-Cutting and Metal-Forming Machine Tools
1982	Nuts, Bolts, and Large Screws of Iron or Steel
1982	Crude Oil from Libya
1981	Chromium, Manganese and Silicon Ferroalloys and Related Materials
1981	Glass-Lined Chemical Processing Equipment
1981	Oil
1978	Oil
1978	Nuts, Bolts, and Large Screws of Iron or Steel
1975	Oil
1973	Oil
1972	EHV Power Circuit Breakers and EHV Power Transformers and Reactors
1969	Miniature Instruments Precision Ball Bearings
1968	Chromium, Manganese, and Silicon Ferroalloys and Refined Metals
1965	Watches, Movements, and Parts
1964	Anti-Friction Bearing and Parts
1964	Tungsten Mill Products
1963	Manganese and Chromium Ferroalloys and Electrolytic Manganese and Chromium Metals

Website: https://www.bis.doc.gov/232

CONCLUSION

CONCLUSION

The Defense Industrial Base supports the military readiness of the U.S. and its allies and is critical to continued U.S. technological superiority in a number of emerging technology areas. As a customer, investor, regulator, and partner of industry, the DoD is uniquely suited to identify, mitigate, and preempt risks to U.S. industrial capability and capacity.

With the global and political landscape changing regularly, the industrial base must stand ready, during both peacetime and wartime, to meet changing U.S. demand signals. By effectively coordinating with industry, U.S. interagency partners, and allies; and leveraging the legislative and policy tools available to it, the DOD can ensure that the U.S. industrial base remains well-postured to support emerging technology and surge requirements into the future.

In FY2019 the Department continued to mitigate known risks, and identify emerging risks, to shape an industrial base that is robust, secure, resilient, and innovative.

APPENDICES

APPENDIX A: EO 13806 IMPLEMENTATION

Appendix A contains information for official use only, business confidential, and proprietary. This appendix will be provided separate from this report.

APPENDIX B: ACRONYMS

A&D: aerospace and defense

A&S: Acquisition and Sustainment

AFFOA: Advanced Functional Fabrics of America

AI: artificial intelligence

AM: additive manufacturing

AT&L: Acquisition Technology and Logistics

AVIC: Aviation Industry Corporation

BI&A: Business Intelligence and Analytics

C3: command, control, and communications

CAPEX: capital expenditures

CBRND: chemical, biological, radiological, and nuclear defense

CDSE: Center for Development of Security Excellence

CEMWG: Critical Energetic Materials Working Group

CFIUS: Committee on Foreign Investment in the United States

CISA: Cybersecurity and Infrastructure Security Agency

CSG: Council of State Governments

CSGC: China South Industries Group Corporation

CY: calendar year

DARPA: Defense Advanced Research Projects Agency

DIB: defense industrial base

DOC: Department of Commerce

DoD: Department of Defense

DOE: Department of Energy

DOL: Department of Labor

DPA: Defense Production Act

DPAS: Defense Priorities and Allocations System

DSCA: Defense Security Cooperation Agency

DSS: Defense Security Service

DTTI: Defense Technology and Trade Initiative

EBITDA: earnings before interest, tax, depreciation, and amortization

EO: Executive Order

FDI: foreign direct investment

FIRRMA: Foreign Investment Risk Review Modernization Act

FMS: foreign military sales

FY: fiscal year

GAO: Government Accountability Office

GMI: Global Markets and Investments

GaN: gallium nitride

HSR: Hart-Scott-Rodino Act

IBAS: Industrial Base Analysis and Sustainment

IBC: Industrial Base Council

INDPOL: Office of Industrial Policy

IPT: Integrated Product Team

IRAP: Industry-Recognized Apprenticeship Program

ITF: Interagency Task Force

JAMSG: Joint Additive Manufacturing Steering Group

JAMWG: Joint Additive Manufacturing Working Group

JANNAF: Joint Army–Navy–NASA–Air Force

JIBWG: Joint Industrial Base Working Group

JMPS: Joint Munitions Power Sources

APPENDIX B: ACRONYMS

KSTC: Kentucky Science and Technology Corporation

LIFT: Lightweight Innovations for Tomorrow

M&A: mergers and acquisitions

ManTech: Manufacturing Technology

MEP: Manufacturing Extension Partnership

MPP: Mentor-Protégé Program

MxD: Manufacturing times Digital

NASA: National Aeronautics and Space Administration

NCSL: National Conference of State Legislatures

NDAA: National Defense Authorization Act

NDS: National Defense Strategy

NGA: National Governors Association

NIST: National Institute of Standards and Technology

NORINCO: China North Industries Group Corporation

NRMC: National Risk Management Center

NSS: National Security Space

NTIB: national technology and industrial base

NdFeB: neodymium iron boride

O&M: operation and maintenance

OSBP: Office of Small Business Programs

OSD: Office of the Secretary of Defense

OUSD: Office of the Under Secretary of Defense

PIB: Programmatic and Industrial Base

R&D: research and development

R&E: research and engineering

RDT&E: research, development, testing, and evaluation

RF: radio frequency

S&E: science and engineering

SAM: Subcommittee for Advanced Manufacturing

SAR: synthetic aperture radar

SBA: Small Business Administration

SIBWG: Space Industrial Base Working Group

SM-3: Standard Missile–3

SMMs: small and medium-size manufacturers

SOSA: Security of Supply Arrangement

SRHEC: Strategic Radiation-Hardened Electronics Council

STEM: science, technology, engineering, and mathematics

TMIB: Technology Manufacturing Industrial Base

TWT: traveling-wave tube

TWTA: traveling-wave tube amplifier

UAS: unmanned aircraft system

U.K.: United Kingdom

U.S.: United States

U.S.C.: United States Code

USD: Under Secretary of Defense

USD(A&S): Under Secretary of Defense for Acquisition and Sustainment

USD(AT&L): Under Secretary of Defense for Acquisition, Technology, and Logistics

USD(R&E): Under Secretary of Defense for Research and Engineering

USG: U.S. Government

APPENDIX C: DPA TITLE III/IBAS/ MANTECH PROJECTS AND INVESTMENTS

Appendix C contains information for official use only, business confidential, and proprietary. This appendix will be provided separate from this report.

APPENDIX D: KEY INDUSTRIAL CAPABILITIES ASSESSMENTS FY2019

Appendix D contains information for official use only, business confidential, and proprietary. This appendix will be provided separate from this report.

APPENDIX E: SOURCES

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APPENDIX E: IMAGE SOURCES

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